INTERNATIONAL LIBRARY OF TECHNOLOGY

A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN THE ENGINEERING PROFESSIONS AND TRADES OR FOR THOSE WHO DESIRE INFORMATION CONCERNING THEM. FULLY ILLUSTRATED AND CONTAINING NUMEROUS PRACTICAL EXAMPLES AND THEIR SOLUTIONS

WOOL
WOOL SCOURING
WOOL DRYING
BURR PICKING
CARBONIZING
WOOL MIXING
WOOL OILING
WOOLEN CARDING
WOOLEN SPINNING
WOOLEN AND WORSTED WARP PREPARATION

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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the

indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one to select the proper formula, method, or process and in teaching him how and when it should be used.

In this volume a detailed description is given of the wool fiber and of the processes through which wool has to pass before it can be woven into cloth. First comes the process of scouring, by which the impurities incident to the growth of the fiber are removed; then drying, picking, and carbonizing. Consideration is then given to the important process of mixing different colors and grades of wool so as to obtain a desired color or quality. Next, the subject of oiling is taken up, a process by which the fibers are prepared for the succeeding process of carding. The chapters dealing with carding machines contain also detailed descriptions of automatic weighing and feeding machines, balling machines, creels, and burring machines. Careful attention is given to the subjects of card clothing, care of cards, card setting, stripping, and grinding. In the chapters on mule spinning, fully illustrated descriptions are given of the various parts of the mule and their functions. The volume closes by describing the preparation of the yarn for the loom, such as spooling, dressing, beaming, drawing-in, and reeding.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part, when the subject is divided into two or more parts, is complete in itself; hence, in order to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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WOOL

INTRODUCTION

CLASSIFICATION OF TEXTILE FIBERS

1. In order that one may be able to obtain a thorough and comprehensive knowledge of the methods and processes employed in converting any textile fiber into yarn, it is first necessary that the structure of the fiber and its peculiarities shall be thoroughly understood. Especially is this true in regard to wool, which possesses certain peculiarities not shared by any other textile fiber; nor is it sufficient for one engaged in woolen manufacture to understand the wool fiber alone, since cotton, silk, and other fibers are often used in woolen mills in connection with the fiber obtained from the fleece of the sheep.

2. Animal and Vegetable Fibers.—The various fibers used in textile manufacturing are, on account of their origin and the marked difference in their physical and chemical properties, divided into two great classes; viz., **animal** and **vegetable fibers.** To the animal class belong the wool of the sheep and the wool-like hair of certain species of goats and animals of an allied nature, as well as the furs of certain other animals that are used for manufacturing purposes. Another notable member of the animal class of fibers, and one that is second only to wool in importance among the animal fibers, is the silk fiber. The most important member of the vegetable class of textile fibers is the cotton fiber, and then follow, in about the order given,

linen, hemp, jute, and china grass, or ramie, fiber, as well as many fibers of minor importance.

3. Mineral Fibers.—A third class of textile fibers is sometimes made under the head of **mineral fibers.** These include such fibers as asbestos, glass wool, etc., but as these are used only for steam packings, and boiler and pipe coverings, etc., and are such an unimportant portion of the textile industry, no further mention will be made of them.

4. Difference Between Animal and Vegetable Fibers.—As previously stated, the difference between animal and vegetable fibers is marked. Generally speaking, the vegetable fibers are smoother and more pliable than the animal fibers, especially wool, which has a rough, curly nature in comparison and a certain elasticity not possessed by any vegetable fiber.

The difference between the two great classes of fibers is even more marked chemically than physically. Vegetable fibers are composed largely of cellulose, and when burned are readily consumed—leaving a very small percentage of white ash and emitting practically no odor during combustion. Animal fibers may be said to have a nitrogenous chemical structure and are burned with some degree of difficulty, emitting during combustion a pungent odor characteristic of burnt horn or feathers, and leaving a charred, globular residue. Vegetable fibers resist the action of alkalies but are readily destroyed by acids, while animal fibers suffer no deterioration from the action of the mild acids but are quickly destroyed by alkalies. The principal animal fiber, wool, has a rough, serrated surface, is curly, or longitudinally wavy, and is disposed on the fleece in locks, technically **staples,** which are composed of a large number of individual fibers. When placed under a microscope and magnified to several hundred diameters, the appearance of various fibers is seen to vary in

Fig. 1

a marked degree. In Fig. 1, a view is shown of a wool fiber *a*, a cotton fiber *b*, and a silk fiber *c*, as they appear when greatly magnified.

5. **Hair.**—Not only do animal and vegetable fibers differ in physical and chemical structures, but there is also a marked difference in physical structure between certain of the animal fibers. **Hair** has a smoother surface than wool, is straighter, and is not combined in staples, as each fiber grows individually. Between hair and wool, however, there are many gradations, and certain long hair-like fibers are disposed in staples and are commercially classed under the head of wools when, strictly speaking, they should be included among the hair products. An instance of this kind is the case of *mohair*, which, although often classed as wool, is really the long silky hair of the Angora goat. Another instance is that of the so-called *vicugna* wool, which is the product of the vicugna, an animal native to South America and belonging to the same genus as the llama.

It is supposed that originally, when wild, all animals were either hair-producing in their nature, or else were covered with fur, which is in reality fine, thick hair. True wool, as typically illustrated by the fleece of the sheep, is the product of breeding and cultivation, the hairy covering of the wild animal gradually becoming more like wool in its nature in direct proportion to the care bestowed on it and the degree to which it is domesticated. Sheep, if neglected and exposed to inclement weather, show a tendency to revert to their supposed former hairy covering, and the fiber becomes shorter, straighter, and coarser, until sometimes, in high latitudes, it very closely resembles hair.

FIG. 2

In Fig. 2, a microscopical view of hair fiber is shown, from which it will be seen that the hair fiber is somewhat different in physical structure from the wool fiber shown in Fig. 1.

THE WOOL FIBER

MODE OF GROWTH

6. Wool may be said to be a term that, in its strictest sense, applies only to the fleece or covering of the sheep, but which is often extended, for purely commercial reasons, to include certain other animal fibers that are more properly included under the term *hair*. Wool is an epidermal growth of the sheep, and its character depends on the breed of the sheep, the trueness of the breeding, and the locality in which the wool is grown.

The mode of growth of a wool fiber may be seen by referring to Fig. 3, which is a section of the root of a single fiber. The root of the fiber is enclosed in the *hair follicle*, which is a minute sac formed in the skin of the sheep. The skin itself consists of four layers: an outer, or *scarf*, skin composed mostly of dried or dead cells; the *epidermis*, or true skin; a *papillary layer*, filled with minute blood vessels; and finally the *dermis*, or *corium*.

The wool fiber is formed in the hair follicle and is pushed out through the skin in a somewhat plastic form, which, however, soon hardens into the true fiber. The fiber itself is formed of three distinct portions: In the center is a medullary canal like a pith, which is formed of soft, globular cells; surrounding this is a layer of elongated and somewhat spindle-shaped cells, which form the bulk of the fiber; and surrounding the whole is a layer of flattened, horny scales or cells, which in a healthy sheep have a high luster. These outer scales form a complete covering for the fiber and are fastened near the root ends, the top of each scale,

FIG. 3

or portion near the tip, being free and projecting somewhat from the body of the fiber. The scales are overlapped, so that the appearance of a typical wool fiber may be compared to an elongated fir cone. The scales form what are known as the **serrations**, or **imbrications**, of the wool fiber, and are one of the prime causes of the great felting or milling power possessed by wool, and by no other fiber to such a marked degree. It is this felting power that enables a woolen cloth composed of suitable wool to be so amalgamated that one fiber joins another fiber, producing a firm, thick fabric, the distinct individuality of the component threads of the fabric being lost.

The scales of the fiber may be readily noticed by drawing it through the fingers from point to root. If the fiber is drawn in the opposite direction, that is from root to point, it will feel perfectly smooth to the touch, since, as previously stated, the scales project from the fiber in the direction of the point. An idea of the appearance of the scales may be obtained by referring to Fig. 1, where the wool fiber shown may be said to be typical of its kind.

PROPERTIES OF WOOL

7. Felting.—On the number of serrations, together with the natural curly, or wavy, nature of the fiber, the value of any wool as a felting wool largely depends. **Felting,** which is a quality possessed in a marked degree by wool only, may be said to be the amalgamation or matting of the fibers of wool. The small teeth-like projections of one fiber catch into those of its neighbor and become locked together, this being helped by the curly nature of the fiber inclining it to twist around anything that is near. Under pressure and in the presence of some lubricant, such as soap, warm water, etc., the fibers of wool become matted together and identified with one another. This is exactly what happens when a woolen cloth is milled. The cloth is under pressure and in the presence of warm water and soap. Under these conditions, the dried-up cells that form the scales on the

surface of the fiber become softened; the serrations of one fiber become interlocked with those of the next; and the threads of the fabric become amalgamated to such an extent that they can with difficulty be separated. This process of felting, or milling, is accompanied by a shrinkage and the fabric *takes up*.

In order that felting may take place, it is essential that some of the fibers lie in one direction while others point in the opposite; this object is always accomplished during the manufacture of the yarn, by the repeated mixing and blending to which the fibers are subjected. In Fig. 4, a longitudinal section of two wool fibers is shown, which illustrates the method by which the serrations of one fiber become interlocked with those of another. This illustration is, of course, out of proportion, but it will be readily noticed that the fibers must be inclined in opposite directions in order to felt. If they were both arranged side by side with roots and tips together, the serrations of one fiber would readily slide over those of the other fiber, no matter in what direction the fiber was moved.

FIG. 4

Although the serrations of the wool fiber are a prime cause of its felting power, it must be remembered that the curliness and elasticity of the fiber also influence the felting of the wool. Neither the curliness nor the elasticity, however, is the sole cause of felting, as some fibers, like mohair for instance, have a beautiful crimp, or curl, but owing to the lack of sufficient serrations on the fiber, are extremely difficult to felt.

8. The felting value of a wool is largely determined by the number of serrations per inch of the fiber and also by the freedom with which the upper edge of the scale projects from the fiber. The freer the movement of the scale and the more it sticks out from the body of the fiber, the greater is the felting power. For this reason, it has been found that wool fibers

that have been treated with acids or other agents (as for instance, in the process known as **carbonization**, or **extraction**) have a greater felting power than the same fibers before being treated. The acid or other agent seems to open out the scales of the wool so that the fibers are more easily felted. For the same reason, what are known as **pulled wools** (that is, wool that is removed from the skin of dead sheep by first soaking the pelts in, or rubbing the back of the skin with, lime or acid) are often better felting wools than the same grade clipped from a live sheep; the lime or acid, instead of injuring the fiber, actually, increases its felting properties by abnormally extending the scales.

Wool rarely felts on the sheep, owing to the fact that the serrations are filled with a natural grease known as **yolk**, and also because, when on the sheep, the scales all point in one direction; that is, from the root toward the point of the fiber, the root of the fiber being fast in the skin of the sheep. Occasionally, however, in the case of a sick sheep, the wool will felt on the sheep's back in patches, which are called **cots**. These are especially apt to occur on old sheep, particularly ewes 6 or 7 years old, and are due to a scanty supply of the animal grease, or yolk, at the places where the cots occur.

Wool, except for the manufacture of hats and felts, is usually felted or milled after it is spun and woven into cloth, but may sometimes become felted accidentally unless great care is taken at other stages of its manufacture, notably in the scouring process. So remarkable are the felting or fulling properties of some wools, that it is only necessary to beat them in order to form a felted fabric. As a rule, short wools are better felting wools than those of longer staple, since they are usually richer in serrations and generally finer in fiber.

9. Serrations.—Enough has been said (in connection with the structure, mode of growth, and felting power) concerning the serrations, or imbrications, of the wool fiber, to give a knowledge of what is meant by the terms.

Nothing has been said, however, in regard to the number of serrations on the wool fiber, except that the more numerous the serrations, the more valuable is the wool for fulling purposes. The number of serrations per inch of various wools vary from a few hundred to several thousand; in a general way it may be said that the longer and coarser the wool, the fewer are the serrations. The Saxony Electoral wool, which has superb fulling qualities, contains as high as 2,800 serrations per inch, while Australian merino, which also possesses excellent felting properties, has 2,400 serrations per inch. Some of the fine full-blooded merino sheep raised in Vermont for breeding purposes only, are said to have as many as 3,000 serrations per inch. The English Southdown has about 2,000 serrations per inch, while Leicester, a wool of acknowledged inferior felting power, has only 1,800 serrations per inch. While it is true that some wools have even fewer serrations than Leicester, their value as fulling wools is very slight.

10. Softness and Fineness.—These are two very important properties that are necessary in a wool for producing the best grades of cloth. The **softness** and **fineness** of wool vary according to the breed of the sheep and to the state of cultivation to which it has been brought. As a rule, short wools are finer and softer than long wools; but this does not hold true in all cases, since some long wools are very fine and soft, while some short wools are harsh, coarse, and wiry. This, however, is not generally the case. The finer the wool fiber is in diameter, the softer is its feeling. No wool can be soft without a plentiful supply of the natural animal grease or yolk, without which it has a harsh, brashy feeling.

The finest wool is known as **lamb's wool** and is clipped when the animal is about 6 months old. The fiber of lamb's wool also gradually tapers to a point, while wool that has been previously shorn has a blunter point. The second clip, or yearling wool, made when the sheep is about 1 year old, is also somewhat finer than the subsequent, or

fleece clips, although extremely fine-fibered wools are produced among these. There is a great difference in the softness and fineness of wool according to the portion of the fleece from which it is obtained. This subject is properly included under the head of Wool Sorting, and will be taken up later.

There is considerable difficulty in making accurate measurements of the actual diameter of the fiber, on account of its extreme fineness, and also because of the irregular shape of the section, the fibers being round in some instances and elliptical in others. Saxony Electoral wool, one of the finest and best-grown wools in the world, has been found to be about $\frac{1}{2000}$ inch in diameter, varying from this to $\frac{1}{1600}$ inch. Some of the long braid wools are as coarse as $\frac{1}{400}$ inch in diameter, while selected breeding specimens of the Vermont merino are said to run even finer than the Saxony, being known in some instances to approximate $\frac{1}{3000}$ inch, although it is doubtful if this is not an exceptional case. The Australian merino is said to average from $\frac{1}{1400}$ to $\frac{1}{1200}$ inch in diameter, while the breed of sheep known as Southdowns produce a slightly coarser fiber, being about $\frac{1}{1100}$ inch in diameter.

11. Strength and Elasticity.—Wool, in order to produce cloth of the highest grade, must possess **strength** and **elasticity.** Wool is one of the most elastic fibers known to the textile industry, and for this reason is unrivaled in the production of cloth with a *lofty feel*; that is, cloth having that full, soft, elastic *handle* so much desired by the commission house and buyer. The elasticity of wool is no doubt due in some degree to the curly, wavy nature of the fiber, as well as to its natural structure.

To illustrate the elasticity of wool, as compared with other fibers, take a handful of clean, dry, Australian merino, or other high-grade wool, in one hand and compress it into as small a space as possible; then release the pressure, and the wool will resume its original shape. Try this same experiment with a handful of cotton, and it will be seen that the

cotton, after being compressed, will remain in a more or less inert lump, and will not spring back like the wool. When a wool fiber is subjected to tension instead of compression, it is found that the elastic limit, after which it will not return to its original length, is reached after the fiber has stretched from .3 to .5 per cent. of its length. A single wool fiber will support from .5 to 1.25 ounces, depending of course on the fineness of the fiber. Both the breaking weight and the elastic limit, however, will be found to vary greatly with different samples of wool. The strength and elasticity greatly aid in the manufacture of woolen cloth, especially in the spinning of the yarn. That they play an important part in the quality of a fabric is shown by the superior strength and feeling of a piece of pure woolen goods as compared with a fabric manufactured from, or adulterated with, either cotton or cheap wool substitutes.

12. Crimp.—The crimp, or curliness, of the wool is another important factor in its value, since this quality of the fiber aids not only its elasticity but, to a certain degree, the felting power of the fiber. A curly fiber is a great aid in spinning the wool, since it can be drawn finer and a more compact and rounded thread formed. By reason of the curly nature of wool, it is possible to spin a thread containing a very few fibers in its cross-section. Generally speaking, it may be said that the more crimps per inch there are in the fiber, the finer is the wool; that is, the diameter of the fiber. This is not a universal rule as is supposed by some, but serves, however, in the majority of cases as an indication of the diameter of the fiber.

The number of crimps per inch in the wool fiber vary from twenty-eight or thirty in fine wool, as for instance Saxony and merino, to only one or two in coarse carpet wools. While the crimp of the wool fiber is permanent, it is altered somewhat by the amount of moisture in the fiber, and may be taken entirely out by stretching the fiber in hot water. After drying, however, the crimp usually returns, and the fiber assumes its former shape.

13. Soundness.—Perhaps one of the qualities of a wool most desirable to the manufacturer is **soundness** of the fiber. If the sheep have been ill-kept, neglected, exposed to inclement weather, or pastured on ranges where the feed is insufficient, the growth of the wool is stunted and its quality deteriorated. Such a flock will often produce what the buyer terms **tender staple**; that is, the fibers are weakened and are not so strong as the average wool. If a sheep is neglected and starved, even for a few days, there will be a corresponding thin, weak place in the wool, where its growth was stunted during the neglected period. This weak place will remain in the fiber even after the wool has continued to grow. It is said that the most expert buyers can, if there is a weak place in the staple of a lot of wool, tell the month in which the drought that caused it occurred.

It is a well-known fact that alkalies are detrimental to wool; and when a flock of sheep habitually range on an alkaline soil, the fiber will be somewhat weaker than the average. The wool fiber should taper slightly from the root to the tip; but sometimes where sheep are exposed to rough weather, the fiber will thicken up at the tip where it is exposed, and still remain fine near the root, where it is protected from the weather.

Wool being somewhat fibrous and porous, the fiber is easily split; indeed, when the sheep is sick, the fibers often split from the tip toward the root. If the wool is very dull in appearance it is apt to be tender. Sound wool is bright, lustrous, and moderately greasy, or yolked. After a sheep has passed a certain age, say 6 or 7 years, the wool produced is apt to be tender, as well as somewhat deficient as regards yolk.

In testing wool for tenderness, a small lock or staple is taken and its strength tried. It can easily be seen if the wool is weak to any great extent, as it will always break in about the same place.

14. Kemps.—In fleeces from neglected or poorly bred sheep there occur certain bright, shining, straight hairs called

kemps. These hairs are wool fibers that appear to be diseased or dead. They are straighter than the ordinary healthy fiber, and when viewed under the microscope do not show the characteristic scales or serrations of the wool fiber to such a marked extent. Kemps are more or less opaque, while the ordinary wool fiber is somewhat translucent. They occur even in highly bred wool, such as Saxony and merino, but are much more frequently met with among the lower-grade and cross-bred wools. They generally occur about the neck and legs, where the wool gradually merges into hair.

Kemps vary in length, being in some sheep 2 inches long, or even more in some cases. In brown or dark-colored sheep the kemps are black, but in most cases they are white. They never unite with the other wool in forming a thread, but are simply held in place by the other fibers, and on the surface of the cloth will be seen as straight, shining hairs pinioned down by these fibers. In the dye bath, kemps will not dye the same shade as the other fibers, owing to the fact that they do not absorb the dyestuff as readily. This causes them to show up prominently in the finished goods, thus greatly deteriorating the fabric. By careful breeding and care in housing the sheep in cold and stormy weather, the condition of kempy sheep may be greatly improved.

15. Color.—In regard to **color** it may be said that, generally speaking, the whiter the wool, the more highly it is prized, although there are certain shades of natural browns and black wools that are often sought after. The color is not of so much importance as other qualities, unless white or delicately colored goods are to be produced. The majority of wools are white, but there are produced in small quantities brown, black, red, gray, and yellow. The color of the wool is sometimes influenced by the character of the soil on which the sheep ranges.

16. Luster.—Luster may be defined as the bright, or shining, quality possessed by wool in a marked degree. While wool is not as lustrous as silk, it is far more so than cotton. The luster of the wool fiber appears to be due to the

reflection of light from the horny scales that surround the fiber. As a rule, long and coarse wools are more lustrous than the finer and shorter wools. This is due to the fact that the scales of the fiber are larger and flatter and thus form a larger reflecting surface for the light. It may be said that the luster is directly dependent on the size, flatness, and polished condition of the scales, and that any cause that tends to injure the scales will injure the luster of the wool. The luster of wool is often injured in the scouring and drying by the use of too strong or unsuitable detergents and the application of too much heat. The wool of a healthy sheep is lustrous, while that of a sick sheep appears dull and dead. A lustrous wool adds a certain brightness and fresh appearance to the fabric that is manufactured from it.

17. Staple.—By the term **staple, or length of staple,** the length of the fiber is meant. Wools are classified as long- and short-stapled wools. Long-stapled wools are known as **combing wools,** and are combed for coarse worsted yarns. Short-stapled wools are known as **clothing wools,** and are carded for the production of woolen yarns and fabrics.

There is a class of wools between the long- and short-stapled wools which has a medium length of staple, and is known as **fine combing wools.** They are first carded and then combed for the production of fine worsted yarns for ladies' dress goods, worsted suitings, etc.; these wools are sometimes classified as **delaine wools,** and in this country may be said to include all combing wools that contain merino blood. The term, therefore, has come to be somewhat synonymous with Ohio wools.

The length of staple varies greatly with the breed of sheep, and it may also be said that, generally, the longer the staple, the coarser and more lustrous is the fiber. The long Scotch "braid" combing wool has a staple of from 14 to 18 inches, and some specimens have been known with a fiber over 20 inches in length. On the other hand, some of the short

clothing wools are hardly more than 2 or 3 inches in length at the most. It is erroneous to suppose that all long-stapled wools are made into worsted, and all short-stapled wools into woolen yarns. Quite short-stapled wool is now made into the fine grades of worsted yarn by means of the French system of mule-spun worsteds.

18. Hygroscopicity.—The hygroscopic property of wool, or its avidity for moisture, is one of its most marked physical properties. Under normal atmospheric conditions, wool will be found to contain about 14 per cent. of its weight of moisture, but if the atmosphere in which the wool is stored is very damp, it may be found to contain as high as from 30 to 50 per cent. of water. Wool brought from a damp storehouse, therefore, into a warm, dry mill will lose in weight. Sometimes the wool in the mill will become so dry as to contain not more than 6 or 8 per cent. of moisture. In this condition it becomes hard to work and is easily electrified, which leads to the necessity of providing some method of artificially regulating the humidity of woolen card, spinning, and weave rooms.

The moisture seems to be contained in the wool fiber in two conditions: first, in a purely mechanical state as a sponge would absorb water; and second, in a somewhat chemical state as a water of hydration. When dried at 100° (centigrade), wool loses on an average 18.25 per cent. in weight. This percentage is allowed as the standard by conditioning houses.

19. Conditioning.—On the continent of Europe and in England so-called **conditioning houses** are established, where the buyer can determine the amount of moisture in given samples of wool. This is a very great convenience and puts the buying and selling of wool on a sound basis. In this country but very little has been done in this direction, but there should be an understanding between the buyer and seller as to the amount of moisture contained not only in loose wools, but also in yarn and tops. This, with official conditioning houses where the exact percentage of moisture

could be determined, would be of mutual advantage to both buyer and seller.

The method of determining the amount of moisture in a sample of wool is first to weigh it carefully, and then to place it in an oven until the moisture is driven off and the sample ceases to become lighter. The amount of loss in weight and the percentage of moisture that the sample contained is then readily determined.

WOOL SUBSTITUTES

20. In manufacturing certain cheap grades of cloth, it is not always possible to use pure wool even of a cheap grade. This leads, therefore, to the use of **recovered fibers**, or wool that has previously been manufactured into cloth and perhaps worn until the garment is no longer serviceable. Under the head of **wool substitutes**, there are three different grades of recovered fibers, each of which is recovered from certain classes of goods and has a distinctive name and character.

21. Shoddy.—The best of the wool substitutes is known under the name of **shoddy**, and consists of the wool fiber recovered from soft woolen rags that have not been milled, or felted; such as flannels, stockings, and knit goods. Shoddy is also made from the hard waste of woolen mills, although this is often used by the mill in connection with their soft waste and new wool. While shoddy is really pure wool, the fiber loses much of its characteristic wool nature in the manufacturing and pulling apart again to regain the fiber.

When viewed under the microscope, the shoddy fiber is seen to differ greatly from the original wool fiber. The distinctive scales or serrations will be seen to have been more or less injured, and may be entirely wanting in places, while the fiber as a whole may appear to have been stretched.

In the process of obtaining shoddy the woolen rags are torn into a fibrous mass or ground up. Although the rags are first oiled and the rag picker is so designed as to perform this office with the least possible injury to the fiber

itself, still the process of reducing the rags to a fibrous condition necessarily injures the fiber and breaks it until it may be but a fraction of its original length. The loss in the length and the destruction of the regular structure of the fiber make shoddy only fit for mixing with new wool for the production of low-class goods. White shoddy is very rare, since the material from which shoddy is made has usually been dyed previously.

FIG. 5

The appearance of a fiber of shoddy greatly magnified is shown in Fig. 5, and it will be noticed that the characteristic structure of the wool fiber is almost entirely destroyed.

22. Mungo.—Mungo is a wool substitute that is even poorer in fiber structure than shoddy. Mungo is the fiber recovered from hard-spun and milled, or felted, woolen and worsted goods. Owing to the hard milling and felting that the fibers have previously undergone, when recovered they are almost destitute of the serrated, or imbricated, structure of a pure wool fiber. There are two varieties of mungo. The better quality is obtained from new rags that accumulate as clippings in tailor shops. The inferior quality is obtained from worn and cast-off broadcloths, suitings, etc. Mungo is used for low-quality woolen goods in connection with a small proportion of new wool to give strength to the yarn.

23. Extract.—Extract is the wool fiber recovered from union goods; that is, cloths that contain wool and also some percentage of vegetable fiber, usually either cotton or linen. In order to recover the wool alone, and not to have the recovered animal fiber mixed with vegetable fibers, it is necessary to resort to a chemical process. This process for the extraction of the vegetable from the animal fibers is generally known as **carbonization**, but sometimes is spoken of as **extraction**.

The process is as follows: The rags are first carefully dusted and cleaned, and then are immersed in a solution of sulphuric acid of from 4° to 6° (Baumé) strength. The acid solution is usually contained in wooden tanks, and the rags are frequently stirred and moved about so as to insure the thorough mixing of the acid and water. When the rags have become thoroughly saturated with the acid, they are removed and the excess of the solution drained off, after which they are dried at a high temperature, varying from 100° to 110° (centigrade).

This process reduces the vegetable matter to a charred or disintegrated form, while the acid has no effect on the wool. The rags are then crushed and dusted in a carbonizing duster or similar machine, and the vegetable matter removed as dust. The recovered wool fiber may now be treated with a dilute soda bath to neutralize the effects of any traces of acid that may remain in the fiber. This process, with some alterations, is in use to a large extent for removing burrs, chaff, shives, and other vegetable matter from pure wool, superseding the older methods of mechanical burr extraction. It will be thoroughly explained later.

SHEEP

24. Classification.—Having dealt somewhat exhaustively with the structure of the wool fiber, it will perhaps be of advantage to consider the different varieties of sheep from which wool for textile purposes is obtained. Some naturalists recognize but three varieties of sheep: the *Ovis ammon*, or wild sheep, of Asia and America; the *Ovis musmon*, inhabiting the southern parts of Europe and northern portions of Africa; and the *Ovis aries*, or domestic sheep. These naturalists claim that all other sheep are but varieties of the above, being obtained by crossing and breeding.

The best classification of the sheep of the world is that made by Professor Archer in cooperation with noted manufacturers and naturalists. He divides the sheep that are

useful to man into thirty-two distinct varieties, and groups them geographically as follows:

EUROPE

1. Spanish, or merino, sheep
2. Common sheep
3. Wallachian sheep
4. Crimean sheep

ASIA

1. Hooniah, or black-faced, Tibet sheep
2. Cago
3. Nepal sheep
4. Curumbar, or Mysore, sheep
5. Gārār, or Indian, sheep
6. Dukhun, or Deccan, sheep
7. Morvant de la Chine, or Chinese sheep
8. Shaymbliar sheep
9. Broad-tailed sheep
10. Many-horned sheep
11. Pucha, or Hindustan, sheep
12. Tartary sheep
13. Javanese sheep
14. Barwell sheep
15. Short-tailed sheep of Northern Russia

AFRICA

1. Smooth-haired sheep
2. African sheep
3. Guinea sheep
4. Ceylon sheep
5. Fezzan sheep
6. Congo sheep
7. Angola sheep
8. Yenu, or Goitered, sheep
9. Madagascar sheep
10. Bearded sheep of West Africa
11. Morocco sheep

AMERICA

1. West Indian sheep as found in Jamaica
2. Brazilian sheep

This classification includes all the known varieties of domesticated sheep, the fleeces of many of which are never used in American mills but which are nevertheless interesting from the student's point of view.

25. Spanish Merino.—The Spanish merino, of which large flocks formerly ranged on the mountain slopes of Spain, were in times past acknowledged to produce the best wool in the world, but were imported into Germany by the Elector of Saxony, who by careful breeding improved on the original Spanish merino and produced the Saxony wool, which took its name from the Elector of Saxony, and is often known as the Saxony Electoral wool. These sheep were also crossed with the native Silesian sheep, producing another extremely fine breed, the fleeces of which even surpass the Spanish merino in fineness and weight.

The Spanish merino sheep were introduced into Australia and South Africa and flourished there, until at the present

time the wool from these two places is famous. They were crossed with the various English breeds of sheep, and in many instances the qualities and weights of the fleeces improved. Fig. 6 shows the appearance of a fiber of Spanish merino wool greatly magnified.

26. American Sheep.—Regarding American sheep, it may be said that all of the American breeds of sheep were originally imported. Numerous importations of sheep were made from time to time, including such famous breeds as the Spanish merino, Saxony, and Silesian merino, and also many English breeds, as the Lincoln, Leicester, Cotswold, Southdowns, Oxforddowns, etc.

Fig. 6

Fig. 7

America seems to be well adapted for the raising of sheep, and many fine flocks are to be found on this continent. The full-blooded American merino produces a fleece that is superior in regard to fineness of fiber, serrations per inch, and other desirable qualities. The merino has been crossed in this country with the common sheep, and in many states, notably Ohio, very desirable cross-bred wools are produced. Fig. 7 shows a view of the fiber of a full-blooded American merino, and the numerous serrations should be noticed.

27. Long-Wool and Short-Wool Sheep.—It should be remembered that many of the long-wool sheep, such as the Lincoln, Cotswold, etc., do not produce such fine and well-imbricated fibers as are shown in the previous illustrations. In fact, it is customary among some naturalists to make two distinct divisions of sheep; namely, **long-wool and short-wool sheep.** The long-wool sheep are larger

and have heavier bodies and white faces. The fleeces are heavier, and the staple longer and less curly. The serrations per inch are less, and the fiber is more lustrous and less heavily yolked.

Short-wool sheep have smaller bodies and lighter fleeces. Their faces are black, and their legs are generally shorter than those of the long-wool sheep. The staple of the wool is shorter and more curly, while the fiber is more imbricated and the fleece more heavily yolked. Fig. 8 shows the fiber of a long-wool sheep greatly magnified. The fibers are those of a Lincoln sheep.

FIG. 8

28. Weight of Fleeces.—In regard to the **weight of fleeces**, it may be said that the weight varies greatly with the breed of sheep and, generally speaking, the long-wool sheep produce heavier fleeces than the short-wool sheep. Fleeces vary in weight from 1 or 2 pounds to 11 or 12 pounds in exceptional cases. An average fleece may be said to weigh from 4 to 6 pounds. Some sheep are bred to heavy fleeces more or less at the expense of the fineness of the fiber, while others are bred for quality alone.

The following table gives the weights of the fleeces of various breeds of sheep, together with other valuable information.

WOOL CONSUMPTION OF AMERICAN MILLS

29. Domestic Wools.—In the United States, the principal wools used are the so-called **territory wools**, which include the wools raised in the states of North and South Dakota, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho, Washington, Oregon, and California. These wools are largely used in American woolen mills and are generally considered as a good grade of wool. The fleeces of the territory sheep vary from 4 to 7 pounds in weight when in an unwashed state, and lose from 60 to 70 per cent. of their weight in scouring.

Breed	Cross	Quality	Staple	Color	Weight of Fleece Pounds	Kind of Yarn Suited for
Spanish merino . .		Very fine	Short	White	Ram 8 Ewe 5	Woolen
Saxony	Merino and native	Finest	Short	White	5 to 8	Worsted and woolen
Silesian	Merino and native	Finest	Short	White	5 to 8	Worsted and woolen
New South Wales .	Merino and Southdown	Fine		White	2½	Worsted and woolen
Southdown		Fine	Short	White and gray	3 to 4	Woolen and worsted
Lincoln		Good	Long	White	8 to 9	Worsted
Persian		Medium	Long	White, gray, black, yellow, and brown		Worsted
Donskoi		Coarse	Medium	White and gray		Worsted
Hooniah		Soft and fine	Long			Worsted
Curumbar			Short	White, yellow, gray, brown, and black		Woolen and worsted
Gārār			Short			
Deccan		Coarse	Short			
West Indian . . .		Fine and soft but mixed with hair	Short			Woolen
Morvant de la Chine		Coarse but soft and silky	Short	Yellow		Woolen

The state of Texas also produces a large amount of the so-called **Texas wool.** The Ohio, Pennsylvania, and West Virginia merino and cross-bred wools are largely used in the production of fine worsted yarns. The average weight of American unwashed fleeces is about 6½ pounds.

30. Imported Wools.—Of the imported wools, the principal varieties used are the Australian and Cape Merino and cross-bred wools for the fine worsted and woolen trade, and such wools as Persian, Donskoi, China, and braid wool for the carpet trade. Large amounts of mohair are also used of both the imported and the domestic fleeces.

31. World's Wool Supply.—Of the world's wool supply, it may be said that the largest amount of wool concentrated and shipped is obtained from a few ports in Australasia, which is without doubt the most important wool-producing region in the world. The world's wool production per annum by continents is approximately as follows:

Country	Pounds	Country	Pounds
Europe	950,000,000	Australasia	510,000,000
North America	316,000,000	Africa	135,000,000
South America	510,000,000	Central America and	
Asia	274,000,000	West Indies	5,000,000

MOHAIR

32. Although strictly speaking mohair is not wool, yet it is largely used in American mills, and therefore should be mentioned. Mohair is the fleece of the Angora goat, which is indigenous to the mountainous districts of Asia Minor. The hair of this goat more closely approaches sheep's wool in structure than that of any other animal; it is disposed in long, silky staples and possesses a luster that almost rivals that of silk. The staple averages from 6 to 8 inches in length; the fiber is fine and has a very good development of serrations.

FIG. 9

The Angora goat has been introduced into America, and there are now in this country several very successful flocks, notably in California. The fleece is used for ladies' dress goods and plushes. For pile fabrics, mohair is largely used, as the pile obtained is of great durability. Fig. 9 is an illustration of the mohair fiber greatly magnified.

33. Among other animals, the hair or fleeces of which are used for textile purposes, may be mentioned the Cashmere, or Tibet, goat, which furnishes the material for the famous cashmere shawls, the camel, the kangaroo, the ibex, the llama, the vicugna, from which the vicugna wool is obtained, and the alpaca. The three last-mentioned animals are all varieties of the same species.

WOOL SORTING

INTRODUCTION

34. Not only does the wool vary in regard to quality, staple, fineness, etc. in different breeds of sheep, as has been demonstrated, but it also differs widely in these respects when taken from different parts of a single fleece. Thus arises the necessity of separating the various qualities of wool found on the fleece, in order that they may be used for different grades of cloth. The operation of grading the wool found on the fleece into the different qualities and lengths of staple is called **wool sorting**, while the person who performs the operation is known as a **wool sorter.**

Wool sorting constitutes practically the first operation in the manufacture of a piece of woolen or worsted cloth. It may be said that the wool is sorted into as many different qualities as the mill may require, as fourteen distinct qualities of wool are found on a single fleece by an expert sorter. Ordinarily, there is no necessity for making such a large number of sorts, and in some mills running on low-grade goods, perhaps only two sorts may be made, the edges of

the fleeces only being thrown out; while another mill may sort its fleeces into three or four grades, a first, second, and third quality, with perhaps a little of the coarse breech in a fourth quality. On the other hand, a mill that is running on fine goods and making several grades of cloth may make as many as six or eight sorts from each fleece. It is rarely that more than eight sorts are made, and the general tendency each year is to do less and less wool sorting, since the operation is slow and expensive. However, the coarse, rough breech, or britch, and the skirtings, or edges, of the fleece should always be thrown out, since the yarn spun will be rough and uneven if a mixture of coarse and rough, and fine and soft fibers is used.

35. Wool sorting is a trade learned only by long experience. After working at his trade year after year, the wool sorter acquires a sensitiveness of touch and judgment of the grade of a handful of wool that seems to be instinctive. It is said that an experienced wool sorter is able to sort a fleece with which he is familiar in the dark, telling the different qualities of wool by the feeling alone. The wool sorter learns to judge wool by its **feel,** or **handle,** and by this means alone can tell the degree of softness, fineness, and loftiness of a sample of wool, although he is also guided by the appearance of the staple. In separating the different qualities of wool in a fleece, the sorter is guided by this sense of feeling together with his knowledge of the positions of the different qualities on the fleece.

The tools required by a wool sorter are few, and consist first of all of a wire-covered bench on which he may spread out the fleece and through which loose particles of dirt and any other foreign matter, such as straws, sticks, dust, etc., may fall. He also requires a pair of shears to clip off paint and tarry marks with which the fleece is often marked and as many baskets or boxes as there are sorts to be made.

METHOD OF SORTING

36. The fleece as it comes to the sorter is rolled in a tight bundle and is tied up with either a twisted portion of itself or a string or small rope. In the latter case great care must be taken to remove every portion of the rope, as any particle of vegetable matter in the wool will show a different color when the cloth is dyed. In the winter, when the weather is cold, the fleece may have to be warmed before it can be opened, because the cold weather solidifies the natural grease, or yolk, in the fleece and renders it stiff and hard. As soon as the fleece is warmed, the yolk is started and the fleece becomes soft and pliable. After the fleece is opened, the sorter throws it on the wire bench and proceeds to shake and pick out the vegetable matter, such as burrs, straws, sticks, etc. The back of the sheep forms an indefinite boundary that divides the fleece into two parts. The sorter first separates the fleece along this line into two sections. The next operation is to clip off all paint and tarry marks. In countries where the flocks of sheep run more or less together, it is the custom of some herders to mark their sheep with paint or tar, to distinguish them from sheep of other flocks. This fact accounts for the great number of paint and tarry marks found on fleeces.

The sorter now commences to sort the fleece, being guided by his sense of touch and by the appearance and position of the wool. All coarse, harsh-feeling wool is separated from the fine, soft, and elastic portions, and cast into separate baskets. The finest fiber is that grown on the shoulders and sides, while that of the flanks and lower portions of the animal is of a coarse quality. As a rule, all black or dark-colored locks of wool are separated from the white and placed in one lot, which is usually dyed black. If mixed with the white, the dark-colored wool will, even if in very small quantities, make a *bloom* on white yarns; that is, the yarn will not be pure white, but will have a tinge of color.

It must be understood that there are no definite boundary lines between the different qualities of fiber, but that one

quality merges into another, and a sorter may make three or four, or seven or eight, sorts from the same pile of fleeces according to the needs of the fabrics that are to be made. The poor qualities, which must be separated from the good, include all coarse and harsh-feeling wool, those portions of the fleece that are inclined to be very kempy, tender and ill-grown staples, and also all cotted, or felted, portions, as well as the hard lumps of dirty wool, and the paint and tar marks.

QUALITIES OF WOOL

37. As previously stated, there are fourteen distinct qualities of wool that may be obtained from a single fleece, if carefully sorted. These, according to one authority, are as follows (see Fig. 10):

No. *1* is the shoulder, where the wool is long and fine and grows in close, even staples.

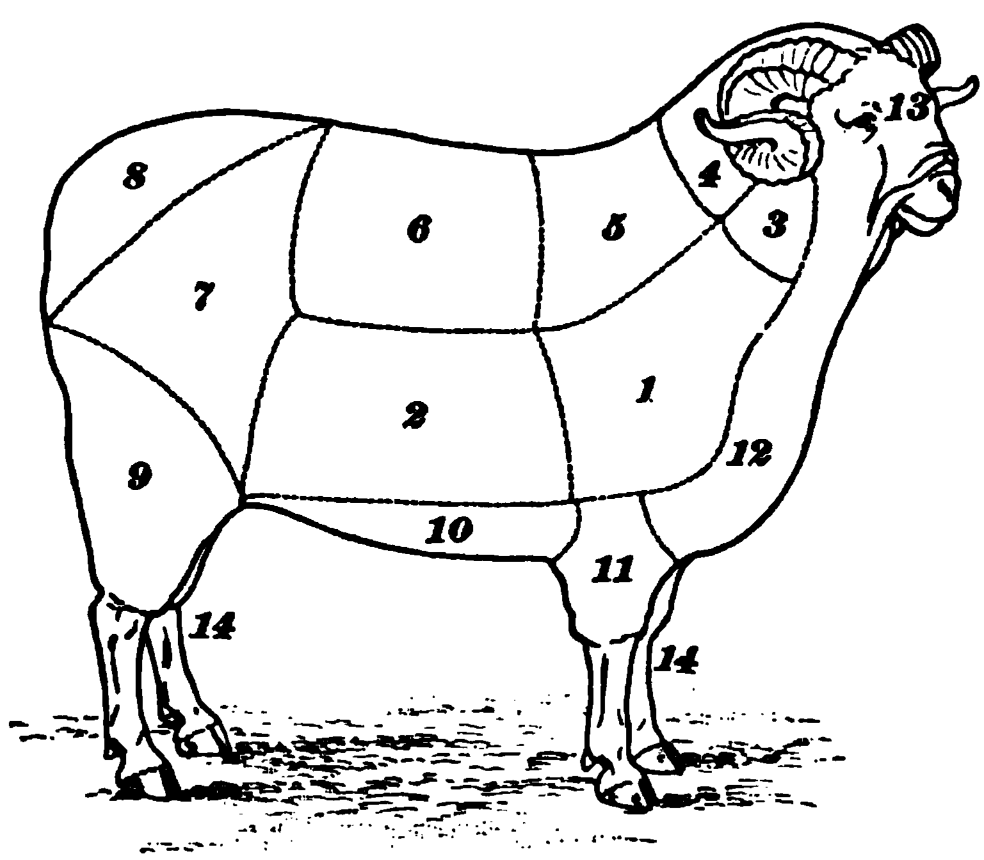


FIG. 10

No. *2* is equally good, but if anything, is inclined to be slightly stronger and the fiber a trifle coarser. The best wool of the fleece is found on these two parts.

No. *3* is the wool that grows on the neck of the sheep, and while the fiber is fine, it is short and liable to contain black or gray hair if the sheep is disposed to their production.

Nos. *4* and *5* produce wool that is somewhat faulty, and the length of the staple is also found to be short.

No. *6*, which covers the loin and back, is still coarser and shorter.

No. *7* produces a wool that is long and strong and hangs in long locks, or staples. It is apt to be very coarse on cross-bred sheep and much resembles the britch.

No. *8* is the britch, or breech, which is the coarsest part of the fleece and is often called *cow-tail* from its resemblance to the coarse tuft of hair on the end of a cow's tail.

No. *9* produces a strong, coarse wool.

No. *10* grows a wool that is short and often dirty from the dirt accumulated when the sheep lies down. It is apt to be finer near the front legs and is commonly known as **brokes**.

No. *11* produces a short and fine wool.

No. *12* is short and fine; the wool is somewhat damaged by rubbing.

No. *13* is the forehead, where the wool is short and coarse and of very little value.

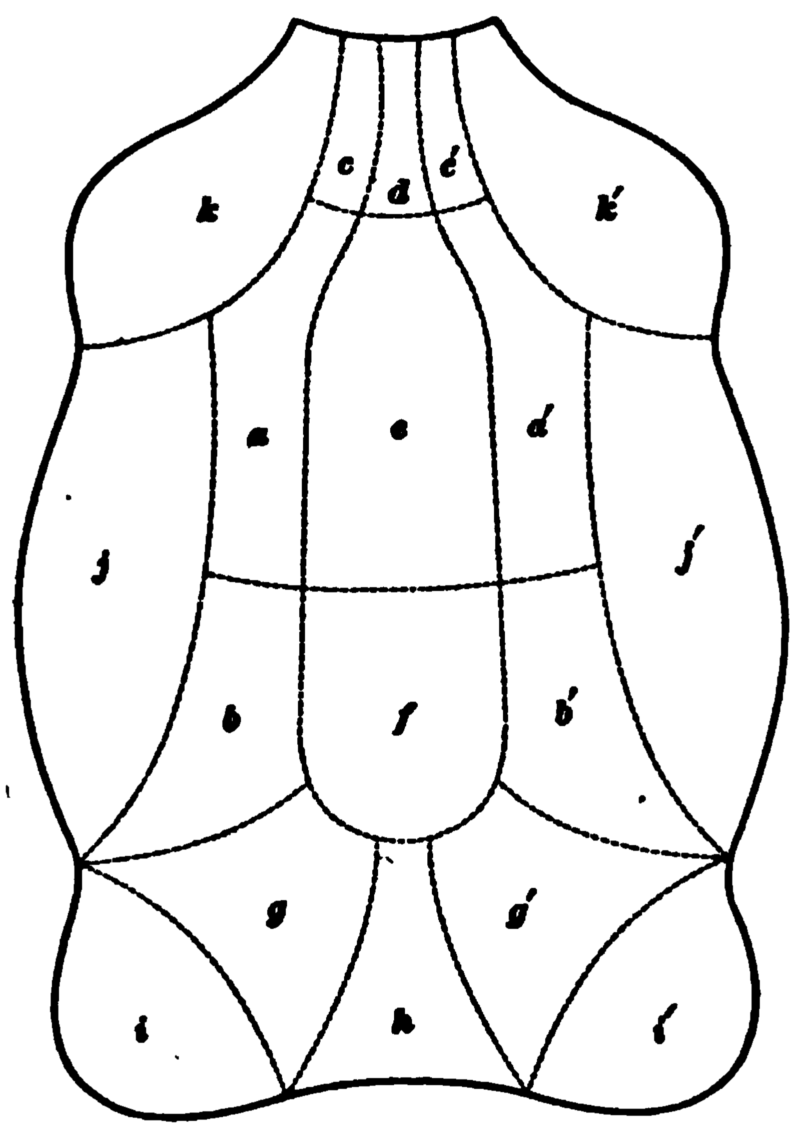


FIG. 11

No. *14* is the legs where the wool is even worse and has no practical value.

When kemps occur in fleeces, they are most liable to be found in Nos. *12* and *8*, although those found on the britch are much longer and stronger.

38. Another excellent division of the qualities of wool in a single fleece is as follows (see Fig. 11): The finest and most evenly grown wool is always found on the shoulders *a*, *a'*.

In some fleeces, this quality extends into *e*, *b*, *b′*, *f* and the quality of the wool at *b* and *b′* is not much inferior, although rather stronger and coarser. These two qualities in the woolen trade would be called **picklock,** and **prime,** or **choice.**

The wool found in position *d* is frequently finer in the staple, but shorter than *a*, *a′* or *b*, *b′* and apt to be defaced by irregular or colored hairs. When free from these defects, it forms a superquality. The qualities *c*, *c′* shade into those on each side of them, and as they form the apex of the shoulders are shorter and less closely grown than *a*, *a′*. The quality of *f* closely resembles that of *b*, *b′*, into which it shades. For many purposes *a*, *a′*, *b*, *b′*, *e*, and *f* are frequently used as one quality.

After passing beyond *f* and back to the flanks of the sheep, the wool becomes long and coarse, the best being found at *g* and *g′*.

At *i*, *i′*, and *h*, the coarsest part of the fleece is reached, where the wool grows in large locks of coarse hair. The former are called the breech, or britch, locks and can only be used for coarse yarns.

39. Perhaps the best division of the different qualities on a fleece is that which separates the varieties of wool as follows:

The Shoulders and Sides.—The wool grown on these parts is remarkable for length and strength of staple, softness of feeling, uniformity of character. It is usually the choicest wool in the fleece.

Lower Part of Back.—This also is wool of a good, sound quality, resembling in staple that obtained from the shoulders and sides, but not so soft and fine in fiber.

Loin and Back.—The staple here is comparatively shorter, the fiber is not so fine, but the wool on the whole is of a true character. In some cases, however, it is liable to be a trifle tender.

Upper Parts of the Legs.—Wool from these parts is of a moderate length, but coarse in fiber and possessing a

disposition to hang in loose, open locks. It is generally sound, but liable to contain vegetable matter.

Upper Portion of the Neck.—The staple of wool clipped from this part of the neck is of an inferior quality, being frequently faulty and irregular in growth as well as full of thorns, twigs, etc.

Central Part of the Back.—This wool is nearly like that obtained from the loins and back, and is rather tender in staple.

The Belly.—This is the wool that runs quite under the sheep between the fore and hind legs. It is short, dirty, poor in quality, and frequently very tender.

Root of Tail.—The fiber is coarse, short, and glossy and the wool often runs with kemps or bright dead hairs.

Lower Parts of the Legs.—This is principally a dirty and greasy wool in which the staple lacks curliness and the fiber fineness. Usually it is burry and contains much vegetable matter.

The Head, Throat, and Chest.—The wools from these parts are classed together, all having the same characteristics. The fiber is stiff, straight, coarse, and covered with fodder. The wool is also apt to be kempy.

The Shins.—This is another short, thick, straight-fibered wool, commonly called **shank.**

WOOL-SORTERS' DISEASE

40. This disease, which frequently attacks wool sorters engaged in sorting dusty wool, especially the Eastern or Asiatic wools, first appears as an ordinary cold accompanied with oppression of the chest, severe headache, and profuse perspiration. The temperature of the patient rises and a cough appears. The respiration becomes harder and the pulse weaker and weaker until in three or four days the man dies. **Wool-sorters' disease** seems to originate in the dust of certain infected wools, which when drawn into the lungs of a person produces a disease that is evidently due to the presence of bacilli.

The worst wool for producing wool-sorters' disease has been found to be what is known as Van mohair. Other wools that are liable to be infected are Turkey mohair, Persian wool, alpaca, camel's hair, and the wool of the Cashmere, or Tibet, goat.

GLOSSARY OF TRADE TERMS USED IN CONNECTION WITH WOOLS

41. Alpaca.—The wool of the Peruvian sheep, or alpaca, which is related to the llama, both belonging to the same genus as the camel.

Angora.—A district in Asia Minor which gives its name to the Angora goat, from which mohair is obtained.

Anthrax.—The scientific name for wool sorters' disease.

Braid Wool.—The fleeces of lustrous- and bright-haired sheep; such as Lincoln, Leicester, Cotswold, etc.

Britch.—Coarse wool from the breech of the sheep.

Brokes.—Short, dirty wool.

Buck Fleece.—The fleece of a ram.

Carbonization.—The chemical process of destroying any vegetable matter found in wool.

Cast.—The fleece of a rough, badly bred sheep.

Classification.—American wools are classified according to condition, staple, and quality.

Clothing Wool.—Clothing wool is the wool of short-haired sheep, which is commonly carded for the production of woolen yarns and fabrics.

Combing Wool.—Long-stapled wools that are combed for producing worsted yarns.

Condition.—This is the state of the fleece as it comes to the market after the first washing. The sheep are driven into the water courses and part of the dirt and grease washed out before the shearing.

Cots.—Bunches of wool that have felted on the sheep's back, due to an absence of yolk, or grease, at the place where the cot occurs.

Delaine Wool.—Delaine wools are those of merino blood prepared for combing by first being carded, and are used for the production of fine. and medium worsted yarns. Delaine wools comprise practically all combing wools with a trace of merino blood. In America the term is practically synonymous with Ohio merino and cross-bred wools.

Elasticity.—The lofty, or springy, nature of certain fibers, notably wool.

Extract.—Wool derived from waste woolen materials that have been mixed with vegetable materials, as cotton, linen, etc., either in weaving or otherwise.

Extraction.—This term is synonymous with the term carbonization.

Felting.—A property of wool that enables a number of fibers to join and interlock with one another until they form a compact whole and the fibers cannot be separated. In America, the semiannual clip of portions of Texas and California is sometimes known as felting wool.

Flocks.—The waste of finishing machines in cloth mills, which is again used as a wool substitute to cheapen yarn and make it bulky.

Fulling.—See Felting.

Grease Wool.—Wools that have not been scoured are known as grease wools or are said to be in the grease.

Hog, Hogget, or Teg Fleece.—The first fleece of a sheep that had not been shorn as a lamb, taken when the animal is about 1 year old.

Imbrications.—A word that is practically synonymous with serrations and indicates the serrated, or imbricated, structure of a wool fiber.

Kemp.—A solid, glazed, dead, horny hair found on badly bred fleeces, rarely over 1½ or 2 inches long, which cannot be twisted into the thread in spinning and will not dye the same shade as the rest of the wool.

Lamb's Wool.—The fleece of a sheep taken when the animal is about 6 months old.

Luster.—The glossy, shiny, or bright appearance of certain fibers due largely to the reflection of light from their

surfaces, more particularly noticeable in long and coarse wools, and especially noticeable in alpaca and mohair.

Mohair.—The hair or wool of the Angora goat.

Mungo.—A wool substitute derived from hard-spun and felted woolen and worsted goods.

Noils.—The refuse or short fibers of combing wools that are removed from the longer fiber by the comb during the combing process and which are often used as a wool substitute in connection with pure wool for the production of woolen yarns.

Pulled, or Skin, Wool.—This is the wool of slaughtered or dead sheep. Generally speaking, pulled wool is considered inferior in quality to the wool or fleeces removed from live sheep. This class of wool is not clipped or sheared from the sheep but the skin is plunged in lime water or rubbed with acid, which loosens the roots of the wool, whereupon it can be easily pulled away from the skin. Some varieties of pulled wool felt very easily owing to the fact that the serrations of the fiber are somewhat opened out.

One advantage of pulled wool is that the fibers are whole, whereas in wool that is sheared, unless the process is performed skilfully, there are liable to be short fibers that are cut twice; that is, the shearer in making two successive cuts will cut off the root ends of fibers that were cut from the skin at the preceding time. The sorting of pulled wool is a difficult task, as the wool does not come away from the skin as a whole fleece but in detached portions. The wool is often impregnated with dust and lime and is apt to give rise to wool-sorters' disease.

Quality.—This term denotes the fineness of the fiber and other desirable attributes of first-class wool. In the American worsted trade the qualities are as follows: Picklock; XXX; XX; X; No. 1, or ½-blood; No. 2, or ⅜-blood; No. 3, or ¼-blood; coarse; and common.

Picklock is the finest quality of wool and is supposed to be the wool of the pure-bred Saxony sheep. *XXX* is the first cross of the merino and Saxony. *XX* is the quality of the full-blooded merino. *X* is the three-quarters blooded merino.

Nos. 1, 2, and 3 indicate the variations in purity of blood from the merino and the common sheep.

Scouring.—Wool washing by mechanical and chemical processes.

Scoured Wool.—Wool from which the yolk, or animal grease, has been removed by the process of scouring.

Serrations, or Serratures.—The fine scales, or points, that project from the surface of wool fibers and that interlock with each other in the process of felting.

Skirting.—Separation of the inferior portions of the fleece generally found around the edges and known as skirts, or skirtings.

Shoddy.—The worked-up waste of unmilled, soft woolen and worsted goods.

Shurled Hogget.—The first fleece from a sheep after it has been shorn as a lamb; that is, the fleece of a yearling sheep that had the lamb's wool removed.

Shearlings.—This is a short wool obtained from the skins of sheep shorn just before slaughtering and is largely used by hatters.

Staple.—A lock of wool formed naturally on the sheep's back by a number of fibers clinging together. Wools are classified, according to length of staple, into clothing and combing wools.

Tags.—Short dung locks that are found on fleeces and which are due to improper care and housing of sheep.

Toppings.—These are hard lumps of matted fibers and dirt that must be cut off by the sorter. They are present only to a small extent in well-bred sheep.

Unmerchantable Wool.—Wool poorly washed is known as unmerchantable.

Unwashed Wool.—Unwashed wool is that which comes to the market without a preliminary washing.

Wether Fleeces.—All fleeces shorn from a sheep after the hogget fleece has been removed are known under the general term of wether fleeces.

Yearlings.—The fleeces of 1-year-old sheep.

Yolk.—The natural grease found in the wool of sheep.

WOOL SCOURING

DUSTING

1. Objects of Dusting.—Previous to scouring, the wool as it comes from the sorter is in the majority of cases passed through a machine known as a **duster**. The object of dusting grease wools is, as far as possible, to remove before scouring such foreign impurities as lumps of dirt, dust, shives, etc. The reason for this is that, as all such impurities are detrimental not only to the finished goods but to the facility with which the processes of manufacture are accomplished, it is advantageous to commence to remove them at as early a period as possible. The wool sorter is supposed to remove burrs and large particles of dirt from the wool during the process of separating the fleece into different qualities, but it is impossible for all impurities to be removed at any one time; and, in fact, they are not all removed until the wool is practically ready for spinning. It is of particular importance to have the wool as free from foreign matter as possible before it is scoured, as the saving in soap and scouring liquor when the wool is dusted and freed from sand, chaff, etc., is very apparent.

2. Another object, although a subsidiary one, is to deliver the wool to the scouring machine in a more open and *lofty* condition, as it is found that scoured wool which has previously been passed through a duster leaves the washing machine more thoroughly and evenly scoured and brighter looking. The reason for this is that the stock is not only partly cleaned by the dusting, but is also opened up so that the scouring liquor will penetrate every portion of it and thus render the scouring more even and more thorough.

TYPES OF DUSTERS

CONE DUSTER

3. Principle of Construction.—The principle on which the **cone duster** operates is simply that of beating the wool

Fig. 1

by means of a rotating cylinder below which is suspended a screen, or grid, that allows the dust and other foreign matter to fall through but retains the stock. The principal features

of the cone duster are shown in Fig. 1, while Fig. 2 is a view of the main cylinder of the machine, which cannot be seen in Fig. 1. This cylinder is cone-shaped, the larger end being 4 feet and the smaller end 26 inches in diameter in some

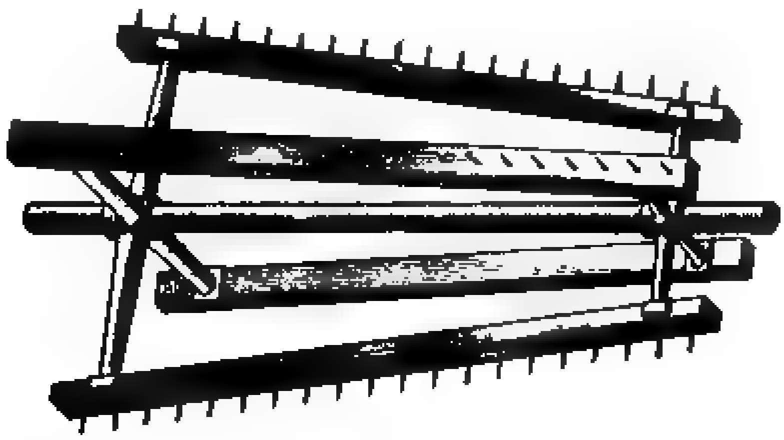


FIG. 2

machines, while the total length is usually about 7 feet. The cylinder is built up on a central shaft with arms, or spiders, to which are attached four wooden lags. Each lag carries iron teeth that project generally about 3 inches from the lag, but in some machines more. Sometimes similar teeth are placed on the frame of the machine so that the teeth lags on the main cylinder will mesh with them.

Below the main cylinder is a grid made in two parts, one of which may be removed from the front of the machine and the other from the rear; the details of one part are shown in Fig. 3. In some machines the grid is so arranged that it may be removed as a whole from one end of the machine. The grid, being removable, is easily accessible for cleaning. Sometimes, instead of a grid, a coarse-meshed screen is used. The dirt that is beaten out by the cylinder falls through the grid into a chamber, from which it can easily be removed.

FIG. 3

4. **The Fan.**—In order to carry off the light foreign matter and dust from the wool, a fan *b* is often used in

connection with the duster, which in this case is shown above the machine in Fig. 1. This is a 24-inch fan so connected to the inside of the cover of the cylinder that a current of air carrying away the lighter impurities is constantly passing through the duster and being delivered outside the mill by means of suitable pipes. Beneath the fan is a screen that retains the wool but allows the dust to be removed. The lower part of the machine is made air-tight, so that the air in the space below the screen will be comparatively still; by this means the current generated by the fan will not hinder the fall of the heavy particles of dirt as they are beaten from the wool and drop through the screen.

5. Feed.—Another feature of the machine is the mechanism for feeding, which consists of a traveling feed-apron, or lattice, on which the wool is fed either by hand or by a self-feed. Immediately over the delivery end of the apron is placed a single large cockspur feed-roll, which, working in conjunction with the apron, delivers the wool to the cylinder. Dusters are occasionally built with two cockspur feed-rolls instead of the single roll.

The method of imparting motion to the various parts of the cone duster is as follows, the references being to Fig. 1: The fan is driven from the pulley *c* on the main shaft of the machine, which drives a pulley *i* on the fan shaft. A small pulley fastened on the main shaft behind the pulley *c* drives a pulley *g* on a stud; fast to this pulley and loose on the same stud is a pulley *f*, which drives a pulley *h* with a cross-belt. Compounded with the pulley *h*, is a small pinion gear that drives a large gear *j* on the apron-roll shaft. The single cockspur feed-roll is driven by a gear compounded with the gear *j*, which drives the gear *p* fast to the shaft of the feed-roll. The main cylinder shaft carries tight and loose pulleys on the opposite end of the machine and is driven from the driving shaft of the room. The main cylinder should have a speed of about 400 revolutions per minute, while the fan should make about 1,000 revolutions per minute. It is not necessary to give any speed calculations in regard to a duster as it is a

very simple machine and it is seldom that changes are made; if a change is made it is usually in the speed of the whole machine, which necessitates changing only the main driving pulley.

6. Operation.—In operation, the wool is fed on the traveling feed-apron and is delivered to the cockspur feed-roll. The stock is then beaten by the teeth on the lags of the cylinder and all heavy dirt drops by gravity through the screen under the cylinder, while the lighter dust, shives, etc., are drawn off by the fan. The stock travels from the small end of the cone-shaped cylinder toward the large end, and is finally thrown through an opening *n* at the rear of the machine ready for scouring. The wool is now open and lofty and the scouring liquor can penetrate it quite easily; thus more even and more thorough work is assured and there is less need of agitation in the washing machine.

A worker *e* is shown in Fig. 1, which is more particularly used in case of dusting card waste, noils, and similar materials. A duster used for grease wools may be built with or without this roll, which is driven from a sprocket compounded with the pulley *h*. This sprocket drives a compound sprocket on a stud that drives a sprocket on the shaft of the worker. The power required to drive a cone duster may be estimated as 3½ horsepower and the machine should be driven by a 3½-inch or 4-inch belt. The floor space occupied by this machine is 9 feet by 7 feet.

SQUARE DUSTER

7. Object of Square Duster.—Another form of duster for grease wools is shown in Fig. 4, being known as a **square duster.** The objeet of this machine may be said to be the same as that of the cone duster; namely, to free the wool of dirt before scouring. It is, however, more particularly adapted to the longer-stapled wools, such as are used in the fine worsted trade and do not require such severe treatment. The cone duster has a tendency to roll short stock and make the wool *pilly*, while on long stock the

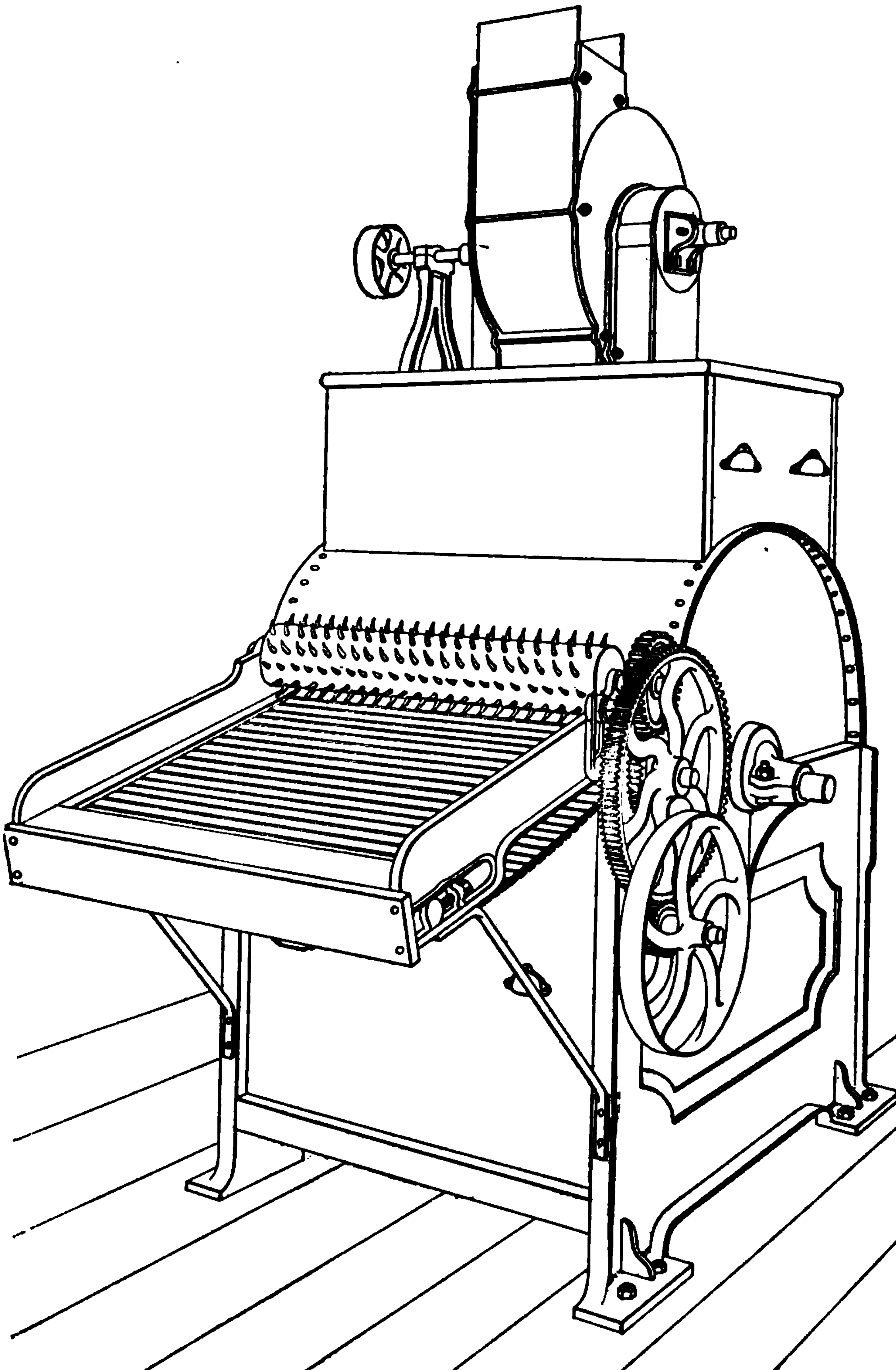


Fig. 4

cone cylinder is apt to make the stock *stringy;* both of these faults are eliminated by the square duster. The principle of the square duster is the same as that of the cone duster, except that in the latter the cylinder is cone-shaped, while in the former the cylinder has the true cylindrical form. The machine is fed by means of a feed-apron, which is made of slats of hardwood, generally maple, as in the cone duster, being fastened on endless belts of leather. The apron runs on cast-iron rolls, which are provided with adjusting screws for tightening the apron when slack. The feed-roll is constructed on the same principle as that in the cone duster and is furnished with cockspur teeth. The advantage of using cockspur teeth for feed-rolls is that when teeth are made curving back from the direction of rotation of the roll they are self-stripping; that is, they clear themselves from wool and the roll does not become matted and choked with stock.

8. **Construction and Operation.**—The square duster is built with or without a fan. In Fig. 4, a fan is shown on the top of the machine. The advantage of a fan is very apparent, as the strong current of air thus generated cleans the wool of all light impurities and conveys them away through suitable pipes. Since the lower part of the duster is made air-tight, the current of air from the fan will not hinder the fall of the heavier particles of foreign matter through the screen, the air being admitted to the fan through suitable openings in the sides of the duster frame.

In operation, the wool is fed to the machine on the traveling apron. It is then taken by the feed-roll and delivered to the rotating cylinder, which in this duster runs downwards, but which in the cone duster runs upwards. The wool in this machine is subjected to the action of the cylinder for about half a revolution and the fleece opened up for the scouring liquor without rolling it or breaking the fibers. The power required to drive a square duster varies with the amount of wool that is being fed to the machine, but may be estimated at 3 horsepower, a 3½-inch belt being sufficient for driving purposes. The machine occupies a floor space of

5 feet by 7 feet. The speed of the square duster is about the same as that of the cone duster.

9. Management.—The management of either duster is a comparatively simple matter and its success depends largely on the manner in which the duster is attended to in regard to cleaning. Dusters, if not properly cared for, soon choke up and in this condition are useless, so far as dusting the wool is concerned. The dust box under the screen, or grid, should be frequently cleaned out, and care should be taken to clean the grid at the same time, because if it is choked up the dirt cannot fall through into the dust box, even if the latter is empty. In putting up the dust pipes for the fan, care should be taken to have as few angles or bends as possible, so as to obtain a good current of air and also to avoid sharp curves or bends. Round elbows with a full sweep and round piping should be used for conveying dust or stock from a duster, or in fact any machine requiring to be thus connected. Sharp angles in dust pipes destroy the force of the air-current and are liable to become choked with refuse. The dust pipes should be as large as the opening of the fan casing and preferably of galvanized iron.

OPEN, OR CAGE, DUSTER

10. A duster occasionally used in small mills is shown in Fig. 5; it is of so simple a type as to require only a brief description. This is sometimes known as an **open, or cage, duster.** The machine consists of a large rotating horizontal cylinder covered with heavy wire screening. Inside the cylinder is a central shaft on which are fixed eight iron cross-bars about 5 feet long, these cross-bars being fixed to the shaft at different angles to one another. The cylinder is provided with a door through which the stock may be entered and removed.

In operation, the wool is placed in the duster and the iron cross-bars, which rotate, beat out all the dust and dirt from the wool and force it through the screen-covered cylinder. The great objection to this machine is that all the dust and

dirt is discharged into the room, where the workmen must breathe the air. Another fault is that the operation is not continuous, the wool being placed in the machine in small lots, dusted, and removed, when another lot is introduced.

Fig. 5

The open duster does good work so far as the stock is concerned, but the slowness and expense of the operation, together with the unhealthy conditions caused by the dust, are fatal to its general adoption.

In England, a duster is known as a **willow** and this term is used to a limited extent in American mills.

SCOURING

11. Object of Scouring.—The operation that follows the dusting of the wool is known as **wool scouring,** or **washing,** and has for its object the cleansing of the wool from the natural and foreign impurities that, if not removed, would effectually prevent the wool from being worked in the after processes of manufacture. In the dyeing, particularly, great trouble is caused by imperfectly scoured wool and it has been found impossible to fasten the colors on such stock. The primary objects of wool scouring, therefore, are to cleanse the wool of the yolk, or natural preservative, a greasy matter that covers the outside of the fiber, and at the same time to remove such mechanically adhering impurities as dirt, pieces of manure, etc., that have not been loosened in dusting. The proportions of the different components of unwashed, or grease, wool vary greatly, but are usually included within the following limits:

	Per Cent.
Moisture	4 to 24
Yolk	12 to 47
Dirt	3 to 24
Wool fiber	15 to 72

From the above list, it will be seen that wool, as it is clipped from the sheep's back, is a very impure article and contains from 18 to 85 per cent. of impurities, the general average being in the vicinity of 60 or 65 per cent. These impurities may be classified in general under three heads: yolk; suint; matter mechanically fixed on the fiber by the yolk and suint.

IMPURITIES IN WOOL

12. Yolk.—In treating of the structure of the wool fiber, reference has been made to the greasy matter with which the wool of sheep is impregnated. This substance is termed **yolk** and is of great service during the growth of the wool in protecting the physical structure of the fiber from injury. While it is true that the wool grease is commonly termed yolk, it really consists of two distinct parts—the *yolk proper*, which consists of substances that require the use of soaps or solvents for their removal, and the *suint*, or portion that may be readily removed by the application of water only.

13. The **yolk proper**, or **wool fat**, as it is sometimes called, has a composite structure, and is composed of substances known as cholesterine and isocholesterine, both in an uncombined state and as salts of oleic and other fatty acids, the latter mainly stearic and palmitic. Wool fat is insoluble in water, but may be dissolved by such solvents as carbon bisulphide, benzine, naphtha, etc.; or it may be removed as an emulsion by the use of alkaline detergents. The removal of the wool fat necessitates the use of strong scouring agents, and were it not for this substance, the wool could easily be washed in pure water. In washing raw wool, therefore, if it contains an excess of this fatty matter it will be more difficult to scour thoroughly, and will require the use of more soap or alkali. Such wools are often termed **pitchy.**

14. Suint.—This is the portion of the wool grease that is soluble in water and is usually included under the general term of *yolk*, which is the common word for wool grease when considered as a whole. **Suint** is really the collected perspiration of the sheep, commonly called wool perspiration, and consists chiefly of potash salts, principally potassium oleate, palmitate, acetate, and other salts of organic acids. Potassium carbonate, chloride, sulphate, and phosphate (carbonate of potash, chloride of potash, etc.) are also present, as well as a small amount of ammonia (about .5 per cent.); these form the inorganic constituents of wool

perspiration. From this it will be seen that the suint, or portion of the yolk soluble in water, is a valuable source of potash salts.

15. Yolk Ash.—In France and Belgium, it is customary to steep wool in tanks before scouring, in order to dissolve the wool perspiration. The dirty brownish water thus obtained is then evaporated in specially constructed furnaces, and a product procured, known as **yolk ash,** from which the potash salts can be recovered. It is said that certain heavily yolked wools will yield, when steeped in warm water, from 70 to 90 pounds of carbonate of potash, and from 5 to 6 pounds of potassium chloride and sulphate per 1,000 pounds of wool. The value of the potash salts obtained in this manner in France alone exceeds $500,000 per annum. In England and America, it is not customary to make any distinction between the wool fat, or true yolk, and the wool perspiration, or suint, the whole being removed in the one operation of scouring, and the waste water allowed to run away in the drains and rivers. Many thousands of dollars are wasted in this manner by American woolen mills, although of late some mills have been taking steps toward retaining these valuable by-products.

16. Analysis of Yolk Ash.—The yolk ash obtained from the water in which the wool is steeped consists of about 60 per cent. of organic matter and 40 per cent. of mineral, or inorganic, substances, these latter consisting largely of potassium carbonate. An analysis of the inorganic matter contained in the yolk ash gave the following results:

	Per Cent.
Carbonate of potash	86.78
Sulphate of potash	6.18
Chloride of potash	2.83
Other metallic elements, as lime, iron, phosphorus, alumina, etc.	4.21
	100.00

Whether wool is steeped for obtaining the potash salts or not, it is always necessary to scour it, since the steeping

only dissolves the suint, or wool perspiration, and does not remove the wool fat, or true yolk. The preliminary steeping of the wool, however, is an aid in turning out the stock bright and lofty.

17. Earthy Matter.—The mechanically adhering impurities of wool consist mainly of **earthy material,** such as sand and dirt, which are held on the fiber by means of the greasy, sticky nature of the yolk and suint, to which they adhere or in which they are enveloped. The mechanical impurities are all foreign, and vary greatly with the character of the soil on which the sheep range, in some fleeces being gritty, and in others consisting of a loamy dirt. The percentage of these foreign substances varies greatly, being sometimes as low as 3 or 4 per cent., and in other cases as high as 20 or 25 per cent., of the total weight of the fleece.

In regard to the amount of weight lost by removing the yolk, suint, and dirt from wool in scouring, or in other words the shrinkage from a grease to a scoured basis, it may be said that there is considerable variation. Long luster wools do not contain as much yolk as those of shorter staple. Merino fleeces average only about 35 per cent. of clean fiber, 40 per cent. of yolk and 25 per cent. of dirt being removed during the preparatory processes of manufacturing. The average shrinkage of American wools may be said to be about 60 per cent., but it is in many seasons a little more than this.

SCOURING MATERIALS

18. The scouring agents in most common use for cleaning wools are soda ash, carbonate of soda, soda, or hard, soaps, potash, or soft, soaps, and ammonia.

19. Soda Ash.—This substance is really an impure form of carbonate of potash, as it contains from 65 to 95 per cent. of the pure carbonate. One of the great dangers in the use of **soda ash** as a scouring agent occurs, not from the carbonate of soda itself, but from the impurities found in

connection with it. One of the impurities most likely to occur is caustic soda, which is injurious to wool even when present in only small quantities. A caustic alkali should not be used on wool or any other animal fiber, since in the presence of hot water free alkali will entirely dissolve the fiber, leaving in the case of wool a milky solution. Tepid water alone will swell the structure of the wool fiber and cause it to lose some of its luster and brilliancy; therefore, the danger of a caustic alkali in the warm (100° to 120° F.) scouring liquor is apparent.

To test soda ash for the presence of caustic soda, first dissolve a small amount in pure water; then add an excess of barium chloride and filter the solution. The filtered solution may now be tried with a piece of litmus paper, the presence of caustic soda being indicated by red litmus paper turning blue; a more delicate test is obtained by the addition of a small amount of phenol-phthalein, the slightest amount of caustic soda immediately turning the solution pink, while its absence will be indicated by the solution remaining colorless.

20. Carbonate of Soda.—This substance, which is the main constituent of soda ash, may be obtained in a very pure form and is the soda crystals, or washing soda, of commerce. It may, however, be tested for caustic soda in the same manner as soda ash, although it is usually free from any such impurity. The ordinary soda crystals contain 63 per cent. of water, but there are several other forms of sodium carbonate (one of which is known commercially as *crystal carbonate*) that are not open to this objection. **Carbonate of soda** is largely employed for scouring the coarser grades of wool, especially those that are very dirty.

21. Soda Soaps.—**Hard soaps** have soda as a base and are quite frequently used for scouring wool. Soda in any form, however, is not to be recommended for the very finest grades of wool. Soda soaps are made by treating caustic soda with any fatty acid; as, for instance, oleic acid, in which case sodium oleate, which is a hard soap, is formed.

22. Potash Soaps.—These soaps are made with potash as a base and are commonly called **soft soaps. Potash soaps** are made in the same manner as soda soaps, that is, by combining caustic potash with some fatty acid, in which case a soluble soap is obtained. It is commonly supposed that soft soap contains more water than hard soap, but such is not always the case. Soda soaps are hard and potash soaps soft because it is the nature of these two substances when used as the base of a soap to form hard and soft soaps, respectively. A soda soap may contain a much larger percentage of water than a potash soap and yet remain hard and firm. When proper precautions are not taken in manufacturing, any soap may be found to contain caustic alkali in a free, or uncombined, state. Potash soaps, contrary to the general opinion, may very frequently contain caustic potash. When this is the case, the soap may have a more severe action on the wool fiber than a soda soap or than even carbonate of soda. A quick test, and one often employed to test soaps for caustic alkalies, is to place a drop of phenol-phthalein on the soap, when a pink color will immediately indicate any free caustic alkali present.

23. Ammonia.—**Ammonia** is frequently added to carbonate and soap scouring liquors and aids in the removal of the yolk. Carbonate of ammonia, which may be obtained in commercial form, is rarely used. The liquid ammonia of commerce, which is added to the scouring bath in small quantities, contains only about one-third pure ammonia, the other two-thirds being water. Formerly it was the custom to scour wool with stale urine, or **lant.** This substance owes its detergent properties to the presence of ammonium carbonate. The wool was placed in tanks containing equal proportions of lant and water and poled around until the yolk and dirt were removed, when it was taken out and carefully drained and rinsed. This process gave results in many ways superior to the present methods. The action of the lant was mild and, when dry, the wool had that soft, *kind* feeling that it should be the aim of every scourer to obtain.

IMPURE SCOURING MATERIALS

24. Great care should be taken in purchasing scouring materials not only because of the necessity of obtaining an agent that will not injure the wool, but also because of the danger of obtaining an article of inferior scouring properties. There are many so-called patent soaps and scouring materials on the market, but they should, as a rule, be avoided, since they are usually expensive and are all based on the ordinary scouring agents with which every scourer is familiar. Soap is one of the easiest articles to adulterate and also one that is rarely tested unless poor results are traced directly to it. Soda soaps will contain a large percentage of water without any noticeable effect on the soap. For this reason, the manufacturer of the soap is liable to allow a large amount of water to be retained for the purpose of adding weight. To determine the amount of water in a sample of soap, weigh it carefully and then reduce to parings and dry in an oven until the sample ceases to lose weight. Then find the loss in weight, and the percentage of water is easily determined. There is a great loss of scouring power besides the inferior work done, if a soap contains resin, potato starch, or other impurities; in some cases earthy matter is added to a soap for the purpose of increasing its weight. Cases are on record where a potash soap has been analyzed and found to contain 40 per cent. of common salt, a substance of no value as a scouring agent.

A simple recipe for testing soap for impurities is to dissolve a small quantity in water and then add a little sulphuric acid to the solution. The acid breaks up the structure of the soap and all earthy and heavy adulterations fall to the bottom of the solution, while grease and resin, being lighter, float on the surface. The presence of resin in a soap is a disadvantage, especially in the soda soaps, where it most frequently occurs. Resin has a tendency to make the wool yellow; in fact, wool is very apt to have a more or less well-defined yellow tinge if scoured with soda in any form unless great care is taken.

THE SCOURING LIQUOR

25. It may be said that for the finest grades of wool, a fine quality of soap should be used, a well-made potash soap absolutely free from caustic alkali being preferred. The use of soda as an agent for scouring wools that are to be stored for some time before using, invariably results in the yellowing of the fiber and gives the wool a harsh feel. Especially is this true in regard to Australian and other fine wools. For medium and coarse grades of wool, where the strength of the fiber is such that it will resist the action of a stronger scouring agent, soda soap, carbonate of soda, or even soda ash may be used; but in all cases the scouring agent should be free from caustic alkali.

The amount of soap or other scouring agent used should be so regulated that no more than is actually necessary to remove the yolk and dirt is used, and the temperature of the liquor should also be as low as is consistent with the results desired. A potash soap for scouring fine wools should be neutral, and from 3 to 5 pounds should be used to each 100 gallons of water. Ammonia may be added to the liquor in small quantities, or part of the soap may be substituted with ammonia. The water used for the scouring should be soft, as hard water is detrimental, as will be explained later.

For coarse wool, the scouring bath should be made up with from 15 to 20 pounds of sodium carbonate to 100 gallons of water; and for medium grades, soap and carbonate of soda in combination may be used to advantage. Some scourers test the scouring liquor for strength by means of the hydrometer, using a carbonate-of-soda liquor of from 1° to 2° Twaddle, depending on the class of the wool to be treated.

26. Preparation of Scouring Liquor.—The scouring liquor may be prepared by first dissolving the detergent to be used in a pail of boiling water, which is constantly stirred. This makes a stock solution and is added to the heated water (100° to 120° F.) in the washer until an emulsion is formed of the right strength, that is soft and smooth to the fingers

when dipped into it and rubbed together. A sample of wool may now be washed, by hand, in the liquor and the liquor squeezed out; if it springs with elasticity on being released and has parted with its grease and dirt, though its natural feeling has not been injured, the liquor is in good condition for scouring.

27. Strength of Liquor.—In scouring wool, the fineness and strength of the fiber should always govern the strength of the liquor used, not the amount of dirt and yolk in the wool, since the finer wools are often the heavier yolked and the fiber would be injured by a severe scouring agent.

In America, the suint is not removed from the wool by steeping before scouring, as in Continental Europe; thus the carbonate of potash that it contains will aid in the scouring of the wool and a smaller amount of scouring material will be necessary.

28. Temperature of Liquor.—In regard to the proper temperature of the scouring liquor, it may be said that a temperature that the hand can just comfortably bear is sufficient, from 100° to 120° F. being the heat generally allowed. The temperature should never be more than 120°, as under the most favorable conditions the natural qualities of the wool are liable to suffer, the luster especially being liable to be diminished. However, many scourers if working on very dirty clothing wools use a temperature as high as 130°, this being done, however, only because of the difficulty in scouring such stock clean. For scouring alpaca and mohair, the heat should be considerably less and should never be more than 100° F., since the luster of these fibers is of prime importance.

HARD WATER

29. As has been stated, **hard water** is detrimental to wool scouring, this being especially true if soap is used as a scouring agent. The substances that are usually found in hard water are various compounds of lime (calcium), iron, and magnesium, the most common substances being the

various lime compounds. If water containing these substances is used for the scouring liquor, the soap is decomposed and the tallow and fat in it unite with the acids contained in the lime, iron, or magnesium compounds, which are also broken up, thus forming a lime soap. The disadvantage of this is that while ordinary soap is soluble and forms an emulsion, the lime soap is insoluble in water and is deposited on the wool in the liquor. This lime soap is a sticky, pasty substance and completely envelops the fiber, being almost impossible to remove; yet if the fiber is not cleansed, subsequent dyeing of the wool is attended with great difficulty and is liable to be uneven. Two kinds of hardness are liable to occur; namely, *temporary* and *permanent*.

30. Temporary Hardness.—Water that contains in solution bicarbonates of lime, iron, or magnesium is said to possess **temporary hardness,** since the water may be softened by simply boiling. The effect of the boiling is to drive off one-half of the carbonic acid, thus changing the soluble bicarbonates to insoluble monocarbonates, which are precipitated, allowing the softened water to be drawn off. This method of softening water, however, is too expensive for commercial purposes, since the softening takes place only gradually, and it is therefore necessary to boil the water for at least one-half hour.

31. Permanent Hardness.—Water that contains in solution chlorides or sulphates of lime, iron, or magnesium is said to be **permanently hard.** Boiling simply concentrates the hardness of permanently hard water.

If the water available for scouring is hard, means should be taken to soften it before using; otherwise, much of the valuable scouring materials will be wasted in neutralizing or softening the water, and even then there is danger of the results being impaired, owing to the insoluble lime soap being deposited on the fiber and not being thoroughly removed. Some mills arrange a system of pipes and tanks to catch, for scouring purposes, the rain water that falls on the roof. Rain water is always soft and an excellent water for this

purpose. This method is not reliable, however, as during the dry season the mill is apt to suffer from a lack of water of this kind and other means must be used.

32. Softening Hard Water.—There are several methods of softening hard water and there is apparatus especially designed for this purpose; but for wool scouring the cheapest method is to precipitate the lime or other compounds with caustic soda. From 3 to 5 pounds of powdered caustic soda should be added to each 1,000 gallons of hard water, the amount added depending, of course, on the degree of hardness of the water. This will remove both temporary and permanent hardness and works as well with cold as with warm water. The caustic soda precipitates all the lime magnesium and iron salts as insoluble compounds, leaving the water soft and ready for use in washing wool.

EFFECT OF IMPROPER SCOURING

33. Wool properly scoured should be open and lofty and of a clear color; the luster of the fiber should not be impaired. Wool improperly scoured, with too high temperature, too strong liquor, or a liquor in which free caustic alkali is present, has a *harsh*, rough feeling. The fiber is also rendered stiff and brittle, is apt to be yellow in color, and much of the natural elasticity of the wool is injured. The serrations on the surface of the fiber are also injured and the value of the spinning and felting properties of the wool deteriorated.

FIG. 6

Fig. 6 shows the appearance of two fibers of wool under the microscope; *a* is a fiber carefully scoured at a mild temperature and with a suitable detergent, while *b* is a fiber that has been injured by excessive heat or alkali. The appearance of the serrations on the fiber marked *b* shows why wool improperly scoured feels rough and harsh.

34. Effect of Soda.—It is contended by many persons that the use of soda in any form as a scouring agent will produce the results shown at *b*, Fig. 6, it being claimed that soda destroys the nature of the wool and renders it brashy and brittle. To a certain extent this is true, that is, when either soda soap or carbonate of soda is improperly used. It must be remembered that soda in any form is a much more powerful scouring agent than potash and therefore must be used in correspondingly smaller quantities. Potash being milder in its action and present in the wool itself, may be said to be a natural scouring agent; but on the other hand, many scourers, if working on a medium or coarse grade of wool, use carbonate of soda as a scouring agent, and the results obtained by proper treatment justify its use.

SUMMARY

35. The following rules for wool scouring are a summary of what has been previously stated and should be followed in all cases where the quality of the work is an object.

1. A fundamental rule is to use as weak a scouring liquor and as low a temperature as is possible to thoroughly remove the yolk.

2. Nothing but perfectly neutral soaps should be used for the best results, at any rate when the yolk is easily started from the fiber. A potash soap, free from caustic alkali, is to be preferred. When the wool is very dirty and the grease stiff and hard, a slightly alkaline liquor will cut the grease from the fiber more quickly; but the greatest care should be taken to prevent injury to the surface structure of the fiber.

3. The less the stock is agitated, the better will be the results, provided that the dirt is thoroughly removed. When the cellular structure of the fibers is swelled by the action of the warm scouring liquor, the wool is more liable to become felted than when in a dry state and, especially when worsted stock is being scoured, the greatest care should be taken to avoid felting and matting.

4. As the higher-lustered fibers, such as mohair and alpaca, are even more sensitive to heat and free alkali than wool, the greatest care should be taken in washing all fibers of this description where luster is important, both the temperature and strength of the scouring liquor being reduced with advantageous results.

5. The water for the scouring liquor should be soft and should not contain either organic or inorganic impurities, although the former do not occasion as much trouble as the latter.

THE SCOURING PROCESS

36. Introductory.—The old method of scouring wool, which was accomplished by means of kettles or tanks in which the wool was worked in the scouring liquor and rinse boxes in which the stock was rinsed, has given way to scouring by means of scouring, or washing, machines. The method of immersing the wool in solutions of lant, while it gave excellent results owing to the mild action of the lant, was apt to roll and mat the stock by the excessive poling to which it was subjected during the process.

The old process of wool scouring is frequently used today in small concerns, with the exception that potash and soda soaps or carbonate of soda have entirely replaced lant as scouring agents. The stock to be scoured is thrown into tanks that contain the scouring liquor, and worked with poles for 15 or 20 minutes in order to remove thoroughly the yolk and dirt from the wool, which is then forked out and allowed to drain on wooden racks and is afterwards rinsed with pure water in another tank. The great disadvantage of this method is that, in the poling and forking, the stock becomes more or less rolled and felted, causing the fibers to be broken when the wool is burr picked and carded, thus reducing its value proportionately. Modern scouring machines have been constructed, therefore, with a regard to keeping the stock in an open and lofty condition as well as cleansing it of its yolk, or natural grease, and are so arranged as to agitate the wool as little as possible consistently with

removing the impurities; and since this is the case the stock should come from the washer open and lofty, free from grease and dirt, and having a bright, natural color with the luster but little impaired.

The essential parts of a scouring machine are a long bowl, or tank, which contains the liquor; a mechanism for propelling the stock through the bowl; at one end a feed-apron, and at the other a pair of heavy squeeze rolls equipped with weights for the purpose of squeezing the liquor from the stock and returning it to the bowl. The machines should be so constructed that two or more may be coupled together, making a combination of two, three, or four bowls as is desired.

THE RAKE WOOL WASHER

37. A type of washing machine that was formerly used to a great extent is the **rake machine,** which consists of a long bowl *a*, Fig. 7, with the usual feed-apron and squeeze rolls, the stock being propelled through the liquor in the bowl by means of **stirring,** or **stirrer, forks,** or **rakes,** marked *b*, which are actuated by cranks *c*. In Fig. 7, will be noticed the method of operating the rakes by means of the cranks driven by bevel gears from a central shaft *d*.

The wool on entering the bowl that contains the scouring liquor is immersed by the **duckers,** or extra tines, *e* attached to the first rake and then passed along through the scouring liquor by the rakes. A carrier *f* then takes the stock from the liquor and passes it between a pair of heavy press rolls, which remove the excess of liquor from the saturated stock. There is a tendency in this machine to string the stock in long ropes, owing to the action of the forks, which move in the arc of a circle. Many of these washers are in use today, but they are being supplanted by improved machines.

THE PARALLEL RAKE MACHINE

38. Construction.—This machine may be said to be the best type of wool washer in use at the present day and is largely employed in the scouring plants of American

FIG. 7

mills. The main features of this washer are shown in Fig. 8; it will be seen that it consists primarily of a long iron bowl, which is built in different lengths and widths according to the capacity of the machine. The bowl is usually made 16, 21, 27, or 32 feet in length, the sides being made in sections so that any desired length may be obtained. (Fig. 8 illustrates one of the shorter machines.) The width of the bowl varies from 24 to 48 inches.

The bowl is furnished with a suitable exhaust pipe, through which the liquor can be flushed when too dirty for further use, and is made water-tight so as to retain the scouring liquor. Water is supplied by means of suitable pipes, and the bottom of the bowl is fitted with removable perforated brass or copper plates, which allow the sediment

Fig. 8

of the scouring liquor to be deposited underneath them so as to keep the wool from coming in contact with the dirt removed by the scouring. The bowl also has valve and pipe connections for supplying steam to the liquor in order to heat it to the right temperature, and should be filled with liquor to within about 3 inches of the top. In order to save time in replenishing the bowls, a good arrangement is to have a hot-water tank heated by steam from which hot water can be run into each bowl.

39. Rakes.—The most important feature of this machine, and the one that led to its supplanting the old-fashioned rake machine, is the motion of the rakes, which will be explained with reference to Fig. 9, which shows a larger machine of the same type as Fig. 8. At one end of the bowl is a feed-apron, or lattice, *a* of the usual construction, on which the

FIG. 9

stock to be fed to the washer is evenly spread. The rakes *m* that propel the stock through the liquor are constructed of brass or forged-iron tines, and are fastened to a frame so that they all move in unison. The weight of the rakes is balanced by means of the weights *d*, which relieve the strain on the working parts of the machine when imparting motion to the rakes.

The motion of the rakes is derived from the main shaft of the washer, which is not shown in Fig. 9, being on the opposite side of the machine. This shaft should run about 56 revolutions per minute, and carries a gear of 18 teeth, which meshes with the gear *k*, shown in Fig. 9, having 144 teeth. This gear actuates the rakes by means of a crank through suitable levers, which are so arranged as to result in a rectangular motion, the whole rake frame when actuated by the crank and levers sliding forwards on small rolls placed at *n*. The forward motion of the rakes is generally arranged so as to be about 14 inches.

The rakes drop into the liquor perpendicularly, and when the points of the rake tines are close to the perforated false bottom of the bowl they move forwards in a straight line, carrying the stock with them. When the end of the motion is reached, the rakes are withdrawn from the liquor in a vertical direction and travel back to their first position with the tines clear of the liquor. By this motion, the wool is carried forwards in practically a continuous film with no danger of stringing or felting. Attached to the end of the rake frame at *b* is a **ducker**, or **immerser**, which plunges the wool under the surface of the liquor as it enters the bowl, thus remedying the fault of the stock's floating on the surface of the liquor for some distance.

40. Carrier.—There is a **carrier** at the end of the bowl for the purpose of taking the stock from the liquor and delivering it to the heavy squeeze rolls; this is shown at *e* and consists of an arrangement of brass fingers, or tines. In its forward motion, it carries the stock over a perforated brass table *g*; in its backward motion it is lifted over the wool and

returns to its former position, moving forwards again with a fresh supply of stock. The carrier is operated by means of a crank connected with a gear *l* of 118 teeth, which is driven by a gear of 60 teeth on the main shaft of the machine, on which there are also tight and loose pulleys, 24 inches in diameter, for driving. The speed of the carrier is much faster than that of the rakes, as will be understood by the gearing, the carrier making nearly four motions to one of the rakes; thus there is no chance for the stock to accumulate and roll at the delivery end of the bowl, and the feed to the squeeze rolls is rendered more even.

41. Squeeze Rolls.—The carrier takes the wool to a pair of heavy squeeze rolls *f* that remove the excess of liquor and pass the stock forwards to a traveling apron that drops it on the floor or into a truck. The bottom squeeze roll is sometimes made of brass, but generally a steel roll is used. The great objection to brass for squeeze rolls is that it wears unevenly when in actual operation, and unevenness in squeeze rolls is to be avoided. The top squeeze roll is able to make a slight vertical movement and may be covered with rubber, waste, or cloth, a good rubber-covered roll being preferred, although its expense does not always warrant its adoption. If the top roll is wound with waste, care should be taken to use only pure woolen or worsted waste, because if cotton is used, and the covering wears, the cotton will become mixed with the wool that is being washed, causing specks in the cloth when dyed. Waste- and cloth-covered rolls give excellent service and are inexpensive.

The roll should be springy in order to pass the stock forwards without injury, which is liable to occur owing to the great pressure that is obtained by means of a combination of levers and weights. The weight of the squeeze rolls varies from 1,000 to 1,200 pounds each, and the amount of pressure applied varies from 6 to 8 tons, depending on the amount of stock that is being passed through the washer; the more stock going through the rolls, the greater should be the pressure in order to remove the scouring liquor.

The bite of the rolls is a little above the level of the scouring liquor, which is retained by means of a water-tight partition. The wool in passing to the squeeze rolls does not emerge from the liquor but passes along, actuated by the carrier, in an even sheet. In some machines the bite of the squeeze rolls is at least 6 inches above the level of the liquor in the bowl instead of nearly level as it should be. The consequence is that the carrier pushes the stock up the inclined perforated plate until a considerable quantity accumulates, when it is caught by the rolls and passes through in a bunch, being imperfectly squeezed and often breaking the gear on the end of the squeeze-roll shaft. A receptacle is shown, by dotted lines, at *r* into which the liquor squeezed from the stock by the squeeze rolls falls, and from which it is removed by a small pump on the floor, which discharges through suitable pipes into the bowl near the feed-end of the machine. In operation, the stock is fed to the machine on the feed-apron by hand, or by a self-feed, in which case the apron is dispensed with, the feed dropping the stock directly into the scouring liquor. Occasionally, the wool is discharged from the duster directly into the washer.

42. The wool, being open and lofty, has a tendency to float on the surface of the liquor but is immediately immersed by the copper ducker *b*. The rakes, descending perpendicularly into the stock and then moving forwards in a direction parallel to the bottom of the bowl, convey it without any unnecessary agitation toward the delivery end of the machine, where it is acted on by the carrier *e*. In its passage through the bowl, the impurities are removed by the action of the liquor, and the particles of sand and dirt are loosened from the grease that previously held them to the fiber and drop through the perforated false bottom of the bowl. The carrier then takes the stock from the bowl in an even web and carries it over the perforated table to the squeeze rolls *f*, where the liquor is extracted and the wool passed to the delivery apron, from which it falls either to the floor or into a truck. The wool is now taken to a rinsing tank, through

which there is a strong current of water passing. The water used for rinsing should be soft and free from alkali; otherwise, an insoluble lime compound will be formed with any soap that remains on the fiber; and this being a pasty, sticky substance removed only with difficulty, the subsequent dyeing of the stock will be uneven.

HYDRAULIC WASHER

43. A type of scouring machine known as the **hydraulic washer** is sometimes, although not frequently, met with in American mills. This machine, as its name indicates, carries the wool through the bowl by means of a current of liquor without the use of rakes. The liquor pours from a long inlet extending across the machine at the feed-end, and is supplied by a pump that takes it from a compartment under an inclined carrier table at the delivery end. The wool, as it enters the bowl, is submerged by a revolving drum, and is then carried along by the current of warm liquor to the inclined table and carrier and is delivered in an unbroken web, or film, to the squeeze rolls. As the web passes through the machine in the liquor, it is operated on by duckers that tilt without breaking or otherwise disturbing it. This aids the scouring liquor to remove the larger particles of dirt, which fall through a perforated false bottom.

44. Combinations of Washers.—The description so far given has dealt with a single-bowl machine, but it should be remembered that these washers are built so that they may be arranged in combinations of two or more bowls. In the case of the two-bowl combination, the first bowl contains the scouring liquor, while the second bowl may contain a weaker scouring liquor or be used as a rinsing bowl, thus doing away with the rinse box and consequent handling of the stock.

Scouring machines are coupled together in this manner in combinations up to four bowls for special stock, such as some kinds of carpet wools. The three-bowl combination is used in many mills for fine stock, especially for combing wools. The first bowl contains a strong scouring liquor;

the stock passes through a pair of squeeze rolls into the second bowl, which contains a weak liquor; and then to the last bowl, which is used as a rinser when scouring stock for woolen yarn, but when scouring combing wools is filled with a weak scouring liquor. Combing wools for worsted yarn are never rinsed. It may be said that the best results are obtained by the use of four bowls in the case of dirty clothing wools, the first three containing scouring materials and the fourth tepid water only. This combination will give better results than the three-bowl combination so often used. When the liquor in the first bowl becomes too dirty to use, it is flushed out and the liquor in the second bowl is then run into the first and raised to the required strength, while fresh liquor is made for the second. The production of such a combination is from 8,000 to 12,000 pounds per day, according to the condition of the stock.

In combinations like those described, an extra function is performed by the squeeze rolls. The wool very often contains hard lumps of manure, dirt, and solidified grease, which cling to the fibers with more or less tenacity, but as they pass through the squeeze rolls from one bowl to the next they are broken up and easily removed by the second immersion. The squeeze rolls between the bowls also prevent the dirty liquor of the first bowl passing into the liquor in the second bowl, etc., thus rendering it dirty more quickly than would otherwise be the case. A single-bowl machine requires about 3 horsepower for driving purposes.

SELF-FEED ATTACHMENTS TO SCOURING MACHINES

45. There are three methods of feeding the stock to wool washers in common practice: (1) Allowing the duster to discharge directly into the bowl of the washer; (2) spreading the stock on a feed-apron, which conveys it to the bowl of the washer and drops it into the scouring liquor; (3) by means of a **self-feed,** of which there are several suitable machines.

The advantages of a self-feed are apparent, one of the greatest being that the machine fed by this means does not

require the constant attention of a workman, as all self-feeds are provided with a hopper large enough to hold the stock for 15 or 20 minutes' feeding. In Fig. 10 is shown a self-feed that is built with especial reference to feeding wool

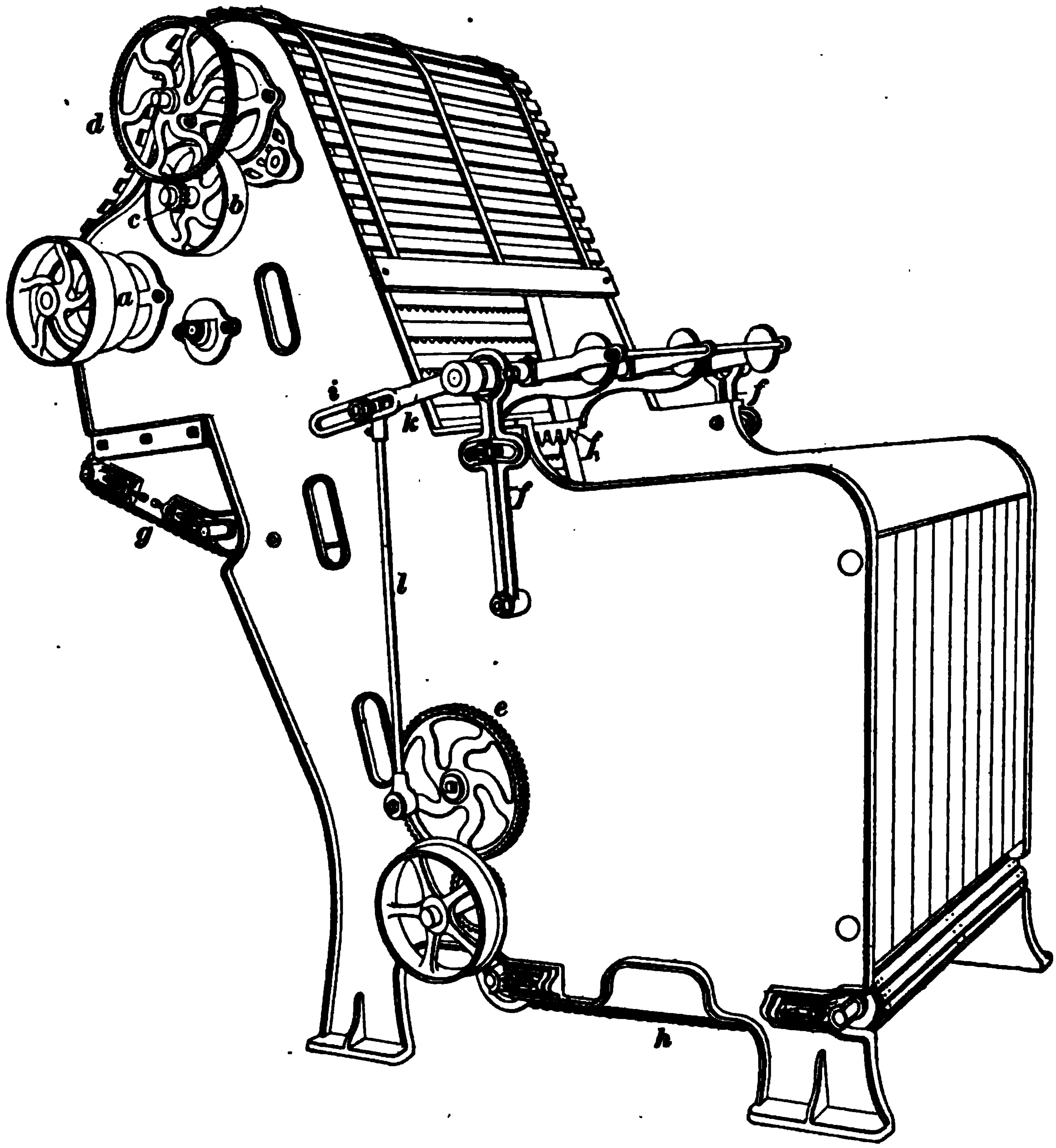


FIG. 10

washers. The main object of this machine is to feed the stock continuously and uniformly to the washer; another object, although a subsidiary one, is that of opening out the stock, rendering it easier for the scouring liquor to penetrate.

46. The principle of the feed is that of a spiked lifting, or elevating, apron, which extracts an amount of stock from the mass in the feed-box, or hopper, in excess of what is needed, the excess being removed by means of an oscillating comb. A stripping, or doffer, beater is so arranged in connection with this apron that the wool which it conveys may be removed from the apron and passed to the machine to be fed. The framework of the feed is of iron, with the exception of the rear of the hopper, which is enclosed with boards. The top of the machine is enclosed with a flexible covering composed of wooden strips, or slats. The elevating apron is made of half-round slats, generally maple, securely riveted to four belts, and is filled with sharp spikes about $1\frac{1}{4}$ inches apart. The apron is driven by means of a pulley *a* on the beater shaft, which drives a pulley *b* on a stud. Attached to this pulley is a gear *c* that drives a gear *d* on the shaft of the top roll of the lifting apron. The gear *c* is the change gear for altering the speed of the apron; an increase in its size drives the elevating apron faster and gives a heavier feed to the washing machine. In the bottom of the hopper is a traveling apron *h* for the purpose of keeping the stock constantly pressed against the elevating apron, thus insuring a constant supply of wool for the lifting apron as long as there is any left in the hopper.

The oscillating comb f_1 is driven by a crank from a gear *e* on the side of the machine. There is a slot *i* in the lever *k* attached to the comb shaft, which allows a change in the position of the connecting-rod *l*, thus increasing or decreasing the throw of the comb. Provision is also made for moving the comb closer to, or farther from, the lifting apron by means of slots in the stands *f* that carry the comb shaft. This allows an alteration in the feed of the machine at this point, as the nearer the comb is placed to the apron, the more stock will be knocked back into the hopper and the lighter will be the feed. The spiked apron on the rear side passes over a binder roll, making an angle with its front side. The doffer beater that strips the stock from the apron is placed at the vertex of this angle, thus helping to prevent

the beater from winding with stock. The beater is usually constructed with four blades attached to spiders on the beater shaft. The beater shaft carries the main driving pulley of the machine and should make about 150 revolutions per minute.

Beneath the doffer beater is a doffer apron *g* on which the stock drops and is carried to its edge, from which it drops into the scouring liquor in the washing machine. This apron is not absolutely necessary, as the beater will allow the stock to drop in practically the same manner; the machine is therefore built either with or without the apron, as desired.

47. In operation, the stock, which has been dusted to remove as much of the loose dirt as possible, is placed in the hopper of the feed, the traveling apron at the bottom keeping it pressed against the lifting apron, the spikes of which are inclined upwards and catch the fibers and locks of wool. The stock is thus lifted to the oscillating comb, which is balanced so as to run smoothly and which knocks off large bunches of wool clinging to the apron. This process makes the feed more uniform and the apron is more evenly loaded. After passing the comb, the stock is carried over the top of the elevating apron to the beater, which takes it from the apron and either throws it directly into the scouring liquor or on the traveling apron, which drops it into the washer. When connected to a scouring machine, this feed occupies a space 6 feet 8 inches in length and is adapted to all kinds of grease wools, including long and coarse carpet wools.

SOLVENT PROCESS

48. Mention has been made that certain volatile liquids, as for instance, *naphtha*, *benzine*, and *carbon bisulphide*, will entirely dissolve the yolk of wool. On this fact there is based a new method of scouring wool known as as the **solvent process.** This method of cleansing wool of its natural grease, while not adopted to a universal extent on account of the expense of proper apparatus for treating the wool, has

been introduced in a few of the largest mills in the country; and it is claimed that the results fully warrant the expense of the equipment, especially where large amounts of combing wool are to be cleansed. By this process, the stock to be scoured, or rather degreased, instead of being immersed in a soap or carbonate scouring liquor, is treated with naphtha in large tanks, or *keirs*.

49. The wool is stripped of its grease by the naphtha and emerges from the closed compartments without the slightest odor, as the liquid is volatile and does not remain in contact with the fiber. The whole process is carried on in the presence of some inert gas that will not form explosive combinations with naphtha nor with air, carbon dioxide being generally used for this purpose; this gas also acts as an extinguisher of fire. The object of this is to guard against the danger of explosions and fires, which are a constant menace where large quantities of explosive liquids, like naphtha, are used. Not only is the degreasing accomplished in the presence of this gas, but the gas is compressed and serves as a motive power for conveying the naphtha through the various *digesters*, etc., that are necessary in an equipment for scouring by this process.

The plant of one large mill that has introduced this method of scouring is so perfect that, although thousands of gallons of naphtha are in motion, there is not the slightest odor to indicate its presence about the works. After being treated with the naphtha, the stock is carried at once to ordinary washing machines, in which it is passed through tepid water only (sometimes, however, a little soap is used); from these it issues absolutely clean and sweet, brilliantly white, and in a perfect workable condition. The previous treatment requires the minimum mechanical action on the fiber in the washing machines, and no highly heated water nor unnatural soaps and alkalies come in contact with the fiber, the potash that occurs naturally in the wool being of sufficient quantity to remove the dirt completely when the wool is treated with warm water in the washing machine.

None of the staple or fiber is broken by this process; neither is the wool tangled nor matted, as is likely to occur in the ordinary method of washing; and the amount of waste in the succeeding processes is greatly reduced. The wool grease, which is known under the French term of **degras**, is retained by this process and forms a marketable by-product largely used in the manufacture of leather and also in the preparation of oils for use in the manufacture of woolen and worsted yarns.

THERMOMETERS

50. A **thermometer** is an instrument for measuring (in degrees) the temperature, i. e., the amount of heat present either in the air or in any other body. The most common form consists of a glass tube sealed air-tight and containing a small amount of mercury, or, as it is commonly known, *quicksilver*. For its effectiveness, the instrument is dependent on the expansion and contraction of mercury under different conditions of heat and cold, thus causing the column of mercury to rise or fall in the glass tube as the case may be, the reading being obtained by means of a graduated scale that registers the height of the mercury column, in degrees.

51. There are three standard thermometers in use; namely, the *Fahrenheit*, *centigrade*, and *Réaumur*. The **Fahrenheit thermometer** is the one most generally used in America for ordinary purposes. The **centigrade thermometer** is sometimes known as the **metric thermometer** and is generally used for scientific and experimental work. This thermometer is the simplest and will no doubt, in time, come into general use. The **Réaumur thermometer** is of very little importance in America, although it finds a limited use on the continent of Europe.

There are two constant, or standard, temperatures on a thermometer, the freezing and boiling points of water, and the different thermometers vary only in the methods of graduating the degrees of heat or cold. The boiling point of water is indicated on the Fahrenheit thermometer by

212°, on the centigrade by 100°, and on the Réaumur by 80°. The freezing point of water is indicated on the Fahrenheit system by 32°, and on the others by zero. In other words, zero Fahrenheit indicates a lower temperature than zero centigrade, while 100° centigrade indicates a higher temperature than 100° Fahrenheit, etc. Fahrenheit readings are indicated by the letter F. following the indicated number of degrees, centigrade by C., and Réaumur by R.

52. Interchanging Thermometer Readings.—The following rules will enable the student to transpose Fahrenheit and centigrade readings from one system to the other.

Rule I.—*To change Fahrenheit readings to centigrade, subtract 32° from the Fahrenheit reading and multiply the remainder by* $\frac{5}{9}$.

EXAMPLE 1.—Change 140° F. to centigrade.

SOLUTION.— $C. = \frac{5}{9}(140° - 32°) = \frac{5}{9} \times 108° = 60°$. Ans.

Rule II.—*To change centigrade readings to Fahrenheit, multiply the number of centigrade degrees by* $\frac{9}{5}$ *and add 32°.*

EXAMPLE 2.—Change 40° C. to Fahrenheit.

SOLUTION.— $F. = (\frac{9}{5} \times 40°) + 32° = 104°$. Ans.

SPECIFIC GRAVITY

53. Definition.—The **specific gravity** of a body is the ratio between its weight and the weight of a like volume of some other substance taken as a standard, which must be invariable. For solids and liquids the standard adopted is pure, or distilled, water at a temperature of 4° C., or 39.2° F.

Rule.—*The specific gravity of a solid or liquid is equal to its weight divided by the weight of an equal volume of pure water at 4° C.*

EXAMPLE.—If a given volume of olive oil weighs 115 grains and a like volume of water at 4° C. weighs 125 grains, what is the specific gravity of the oil?

SOLUTION.— $115 \div 125 = .92$. Ans.

It will be noticed that in this case the specific gravity of the oil is a fraction; this indicates that the oil is lighter than water for equal volumes.

HYDROMETERS

54. For the more convenient determination of the density of liquids, instruments called **hydrometers** are used. The form of hydrometer generally used in mill work is the constant-weight hydrometer, shown in Fig. 11, which consists of a glass tube near the bottom of which are two bulbs. The lower, or bottom, bulb is loaded with shot or mercury in order to make the instrument float upright, while the upper bulb contains enclosed air, which makes it lighter than water. The point to which the hydrometer sinks when placed in pure water is marked zero and the tube is graduated above and below zero, the graduation being sometimes on a piece of paper placed within the tube. As a long tube would be inconvenient, it is customary to have two instruments, one having the zero near the top for liquids heavier than water (the hydrometer rising according to the density of the liquid) and another having zero near the bottom for liquids lighter than water.

FIG. 11

If any substance is dissolved in water, the liquid becomes heavier and more dense. This density is registered in degrees on the hydrometer. For liquids lighter than water the specific-gravity value is commonly used. Two hydrometers are commonly used as standards; namely, *Baumé's* and *Twaddle's*.

Twaddle's hydrometer is almost exclusively used in England, while in the United States and on the continent of Europe the Baumé hydrometer is more generally in use. Twaddle's hydrometer bears a direct relation to the specific gravity of a body, while the Baumé hydrometer with zero in pure water as a starting point, assumes a density according to the percentage of saturation of pure water with common salt.

The table on the opposite page gives a comparison of Baumé and Twaddle hydrometer degrees.

COMPARISON OF BAUMÉ AND TWADDLE HYDROMETERS

Baumé Degrees	Twaddle Degrees	Baumé Degrees	Twaddle Degrees
1	1.4	18	28.4
2	2.8	19	30.4
3	4.4	20	32.4
4	5.8	21	34.2
5	7.4	22	36.0
6	9.0	23	38.0
7	10.2	24	40.0
8	12.0	25	42.0
9	13.4	26	44.0
10	15.0	27	46.2
11	16.6	28	48.2
12	18.2	29	50.4
13	20.0	30	52.6
14	21.6	31	54.8
15	23.2	32	57.0
16	25.0	33	59.4
17	26.8	34	61.6

WOOL DRYING

INTRODUCTION

1. After wool has been scoured, it is necessary to dry it before passing it on to the next process of manufacturing, except when the wool is to be dyed in the raw state. When this is the case, the stock is taken to the dye house direct from the squeeze rolls of the washer, although a slight extraction of the water may be made in some instances by means of the hydro-extractor, a machine that will be described later.

2. Importance of Proper Drying.—The **drying** of the wool is an important process and one on which the condition of the stock as it is received at succeeding processes largely depends. Wool that is dried quickly with a high temperature, has a harsh, unkind feeling, and the fiber loses its suppleness, becoming stiff and brittle; the elasticity and strength of the stock are materially reduced. It is impossible to spin harsh, brittle stock into fine yarn, so that the value of the stock is deteriorated, as the finer the yarn a wool will spin, the greater is its value. If stock capable of spinning to fine numbers is rendered fit only for low numbers of yarn, because of an improper method of drying, there is always a consequent loss to the mill. Cloth made from wool thus maltreated will not have the desired soft, velvety feeling, but will be harsh and rough, the yarn spun from such wool being uneven and lacking in strength and elasticity, and requiring an excessive twist in order to have strength enough to weave.

Formerly wool was dried by spreading it in the open air and allowing the sun and wind to dry it naturally. This method, although slow and laborious, had many advantages over modern methods, and the stock when thoroughly dried

was soft and kind to the touch, none of its natural qualities being injured. The modern process of drying stock with artificial heat, while accomplished with greater speed, is liable if not carefully performed to destroy the life of the wool and render it harsh. Wool that is overheated and baked will also change color and become a dirty yellow shade. The percentage of waste in carding, spinning, and weaving will be increased if the wool is rendered harsh and brittle in the drying, and consequently the cost of the finished product, although it is of inferior quality, will be increased.

From this it will be seen that one of the chief points to be observed when drying wool is to avoid high temperatures; but as it takes longer to dry wool at a low temperature, there is a tendency in some mills to increase the temperature in order to reduce the cost of drying the stock, the fact being ignored that by so doing the saving in time is taken out of the value of the wool, and that the cost of carding, spinning, weaving, and finishing is increased relatively more than the cost of the drying is reduced.

METHODS OF DRYING WOOL

THE COLD-AIR PROCESS

3. There are two general methods of drying wool, the *hot-air* and the *cold-air process*, the former being the modern process largely in use in American mills, while the latter, although a somewhat older process, is sometimes used where the best results are desired, especially for drying fine combing wools.

The cold-air process gives results that are very satisfactory, but is slow, laborious, and expensive, as regards the time required and labor necessary for handling the stock. The wool, however, is left open, lofty, and ready, without any injury to the fiber, for the succeeding operations, not being rendered harsh and brittle by baking as is sometimes the case with stock dried by the hot-air system, nor is there the danger of yellowing the fiber.

TABLE DRYER

4. The cold-air process of drying involves the use of **a table, or platform, dryer.** The principle involved in a table dryer is that of either drawing or forcing air, ordinarily at the normal temperature, through the wet wool, which is spread on wire screens. These screens are so arranged that there is an enclosed space underneath them from which the air may be exhausted by means of a fan, thus drawing a current

Fig 1

of cold air through the wool; or the air may be forced by the fan into the enclosed place under the screen and thus blown through the stock spread on the screen. This latter method is to be preferred, since any process of forcing the air through the stock gives better results than by drawing it, because the wool is rendered more lofty and open when it is lifted by

the air-current than when pressed against the screen, in which case it tends to dry in matted bunches. An ordinary arrangement of a table dryer is shown in Fig. 1.

The machine consists of a wooden, box-like framework *d*, made air-tight with the exception of the top, which is covered with wire screens. At one end, a paddle-wheel fan *c* is attached, being made with an iron frame having a circular opening in which the bearing of the rotating portion is enclosed.

The fan is of the reversible type and may be used either for blowing or for suction. In this case, as the arrow on the main driving pulley indicates, the fan is creating an induced, or suction, draft. A fan with curved blades has considerably greater efficiency than one with straight blades. A fan of this type, however, cannot be reversed.

Occasionally table dryers are operated with warm air, which is forced through them by a fan placed in a separate compartment containing steam coils. This arrangement is sometimes varied by building the dryer as shown in Fig. 1 and placing steam pipes under the screen, the fan forcing the air through the pipes and screen. The disadvantage of using heat in a table dryer is that the heat is unconfined and the operation of drying is attended with more or less inconvenience to the operator. The speed of a fan for a table dryer should be from about 1,000 to 1,200 revolutions per minute.

The principal objection to a table dryer is the slowness of the operation and the lack of continuous motion, as each lot of stock must be spread wet on the screen of the dryer and when dry removed by hand. Such a dryer as shown in Fig. 1 can easily be constructed by an ordinary carpenter, with the exception of the fan, which must be purchased. Fans suitable for table dryers are usually made in sizes from 30 to 40 inches in diameter.

HOT-AIR PROCESS

5. The general method of drying wet wool from the washing machine is with some form of hot-air dryer, of which there are several of standard manufacture on the market. The drying machines in some mills are fed directly from the washers, while in others the wool is first placed in a hydro-extractor and the excess of moisture removed, after which it is fed to the dryer either by a self-feed or otherwise.

When fed directly from the scouring machine, the wool is transferred to the dryer by means of an endless apron, or lattice. This is a very economical way of manipulating the stock, as there is no handling from the time the greasy stock is placed in the self-feed of the scouring machine until it is deposited, all scoured and in a dry and lofty condition, by the delivery apron of the drying machine.

The wool is dried in a hot-air dryer by means of warm air heated by steam pipes placed either in a separate compartment or in the dryer itself and circulated by means of fans. The circulation of the heated air is a matter of prime importance, since it is generally conceded that two things produce harshness and a yellow color in drying; namely, too high a temperature and a lack of circulation, in other words a baking of the stock.

MULTIPLE-APRON DRYER

6. This type of dryer is used to a considerable extent in woolen mills, and while not so good as some other types, excellent results may be obtained with proper precautions in regard to temperature. These dryers are generally made with three or five carrying, or drying, aprons, hence the name **multiple-apron dryer.**

7. Construction.—A section of a five-apron dryer is shown in Fig. 2; it will be seen that the principle of this machine is simply that of carrying the wool through a heated chamber by means of traveling aprons. This dryer is usually

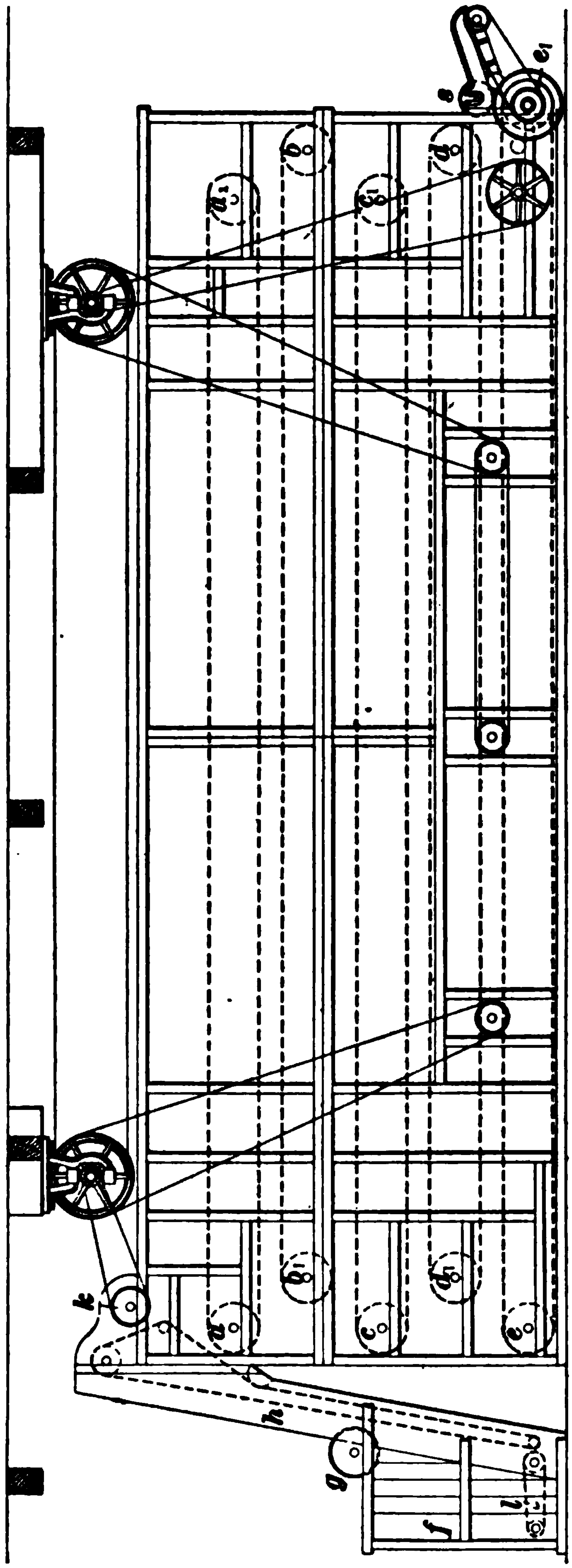


FIG. 2

constructed with a hardwood frame and has the sides enclosed either with wood or sheet-iron panels. A dryer constructed of wood and lined with tin holds the heat better and is more comfortable to work around than one constructed of sheet iron. The wood, however, should be especially kiln-dried; otherwise when the dryer is heated it will, in the course of time, shrink badly. The air is generally heated by steam pipes in a separate chamber running along the side of the machine, and blown into the drying chamber by means of powerful fans. The carrying aprons are often made of wooden slats especially prepared to withstand a heat of at least 250° F. without catching fire, but it is preferred to have them made of woven wire, since the heated air then has a better

chance to circulate through the wool, as it reaches it from the under side as well as from the top.

8. Operation.—In operation the wool is placed in the hopper of the self-feed *f*, and is pressed against the lifting apron *h* by the traveling apron *l*. The stock is taken from the mass in the hopper by the lifting apron, and any excess of wool that is taken is knocked off by a revolving comb *g*, thus evening the feed. The wool is deposited by the lifting apron on the top apron $a a_1$ of the drying machine, being stripped from the elevating apron by a beater at *k*. As the wool travels along the apron, it is subjected to currents of heated air from fans located at the sides of the machine, the heated air being supplied by compartments at the side of the machine filled with steam coils.

The wool travels along the apron from *a* to a_1, and then drops on to the next apron, in so doing being turned over and thus exposing to the heat the portion of the stock that was underneath while on the apron $a a_1$.

The wool travels along from *b* to b_1, and is then dropped on the apron $c c_1$, and so on. Each time the wool drops to another apron it is turned over, so that all portions are thoroughly exposed to the heat. At the end of the bottom apron, a squeeze roll *s* is shown. This is attached only when the dryer is used for drying carbonized wools. The object of the roll is to pulverize the carbonized vegetable matter and thus render it more easily removed by the carbonizing duster. The steam pipes in a dryer of this description are sometimes placed in tiers between the aprons, thus doing away with the fans; this, however, is quite apt to bake the stock, owing to a lack of circulation of the heated air in the chamber.

9. High temperatures in a dryer of this description should be avoided and it is better for the stock to have the aprons run somewhat slowly and have a lower temperature than to have a high temperature and drive the aprons faster. The temperature in this type of dryer should not be allowed to be higher than 160° F. if the best results are desired.

The speed of the drying aprons should be so arranged that with the proper temperature the stock will remain in the machine just long enough to become dry and no more. It is better to have the stock delivered slightly moist rather than too dry and with a harsh feeling.

SECTIONAL DRYERS

10. With a common, one-compartment, hot-air dryer it is imperative that a uniformly low temperature (about 160° F.) be maintained in order to prevent harshness and yellowing of the fiber, which are the chief dangers to be avoided in successful wool drying; consequently, the capacity of a dryer of this type is small and the expense of drying great. In order to render the drying of the stock more rapid and at the same time preserve the soft, kind feeling, drying machines are now constructed with two compartments, the first being heated to a high temperature and the second only to a medium temperature. It has been found that the wool is able to stand a high degree of heat when it is quite wet, but this same degree of heat would tend to injure it if dry; thus by entering the stock at a high temperature and then reducing the heat, the stock is rapidly dried and at the same time there is no injury, as when partly dry it is transferred to the other compartment where the heat is less intense.

By subjecting the wool to about 180° F. in the first compartment and then reducing the heat to 110° F. in the second compartment, it emerges from the machine in a condition that is practically equal to the results obtained by cold-air drying and has the advantage of being extremely rapid and of drying the stock in large quantities. The grading of the heat produces a soft fiber free from harshness and with its color unimpaired when dry, which is due to the fact that on entering the dryer, the stock contains a maximum amount of moisture which counteracts the bad effects of the high temperature to which it is subjected, the actual temperature of the stock being much lower than that of the heated air with which it is in contact. The greatest amount of moisture is,

of course, evaporated in the first compartment, and as the wool passes to the next compartment the heat is reduced according to the amount of moisture still remaining in the stock, until it finally emerges from the dryer soft and lofty and with its natural feeling uninjured.

11. Construction.—A longitudinal section of a two-compartment dryer is shown in Fig. 3 (*a*). This machine is constructed almost entirely of wood carefully kiln-dried before being put together, in order to prevent any possibility of shrinkage and consequent opening of cracks after the dryer is in operation. A dryer made of wood, if properly constructed, is to be preferred to one made of sheet iron, since the wood holds the heat better and thus makes the machine not only more comfortable to work around, but more economical to operate. It will be noticed that in this machine only one carrying, or drying, apron is used; this is made of wire cloth of $\frac{1}{4}$-inch mesh and runs over large drums at each end of the machine. The drums are carefully trued so as to insure the perfect running of the apron, which should not run over the edges of the drums. The apron varies in width from 4 to 9 feet, according to the size and capacity of the machine.

FIG. 3

(*a*)

In three- and five-apron dryers there is considerable annoyance, expense, and delay from the breaking of aprons, due to constant bending around drums of small diameter. This difficulty is almost entirely done away with in the single-apron dryers, owing to the large drums over which the apron passes. The apron is driven by a pair of cone pulleys, the driven one communicating motion to a vertical shaft by means of a pair of bevel gears. To the vertical shaft a worm is attached, which works in connection with a worm-gear on the end of the drum shaft. The apron may be immediately stopped by means of a lever, which when operated withdraws a clutch driving the worm. The three-step cone pulleys allow three speeds of the aprons without changing gears or pulleys, and this is ample range for ordinary work. The more moisture the stock contains, the longer it will have to remain in the dryer and, consequently, the slower the apron will have to be driven, and vice versa.

(b)

Fig. 3

The drying of the wool is accomplished by circulating heated air alternately through the stock and steam coils placed in a compartment at the side of the machine. The air is drawn through the layer of stock on the apron by means of powerful steel-blade fans. In a two-section dryer there are four fans, two in each compartment. A transverse section of the machine is shown in Fig. 3 (*b*), which illustrates the mode of circulating the heated air. As will be seen, the dryer is divided into two compartments laterally as well as transversely; in one section are placed the steam coils *a* that heat the air. A fan *b* draws the heated air through the wool, which is spread on the traveling wire apron *c*. As the heated air comes in contact with the damp wool, the water is driven off in the form of steam and a constant current of moisture-laden

air is removed from the dryer by means of a fan placed in the flue *d*.

The large fans for circulating the air are coupled together by belts, and are driven directly from an overhead countershaft, two such shafts being required for driving the machine. From the first countershaft, the apron and fans are driven; the speed should be about 400 revolutions per minute. The second countershaft is driven from the first and drives the self-feed by two belts, one driving the elevating apron through a pulley on a stud, to which is fastened a pinion gear that drives a large gear on the top roll of the apron, and the other driving the stripper, or doffer, beater by a pulley fastened on its shaft. Attached to this shaft is a sprocket gear, which drives a similar sprocket on the feed carrying a crank driving the oscillating comb of the feed through a connecting-rod.

12. Operation of Sectional Dryer.—In operation, the stock is either taken from the scouring machine directly or is first run through a hydro-extractor, which will be described further on, and then placed in the hopper *a* of the self-feed. [See Fig. 3 (*a*).] There is no necessity for a traveling apron in the bottom of the hopper to keep the stock pressed against the lifting apron, as the drying apron is carried outside of the drying chamber and forms the bottom of the self-feed hopper. The elevating apron a_1 takes the stock and carries it to the oscillating comb a_2, where the feed is evened and any large bunches of stock knocked back into the hopper. The moist wool is stripped from the elevating apron a_1 by the beater a_3 and deposited on the traveling wire apron *c* on which the stock passes into the first drying compartment *e*, where the wool is subjected to a strong current of air, heated to about 180° F. and the moisture removed by the fan *d*. The stock then passes to the second compartment *f*, where the heat is reduced to 110° F. and the drying completed, whereupon the wool is delivered onto the floor or into trucks by the drying apron.

The dryer here described is built either for carbonizing or for drying, and when built for the former purpose is arranged

to dry the wool completely in the first compartment, and subject it in the second compartment to a dry heat, which effectually carbonizes the previously chemically treated vegetable matter in the stock. The carbonizing dryer may be used for a wool dryer, but the ordinary dryer does not make an efficient carbonizer, although the stock can be carbonized with one. Carbonizing requires a higher heat than is ordinarily used for drying, and the wool must be dry before it is subjected to this heat. The process of carbonizing will be treated of later.

13. Capacities of Sectional Dryers.—The following table shows the capacity of two-compartment dryers of different sizes, both for ordinary drying and for carbonizing. It will be noticed that the capacity for carbonizing is much less than that for drying, owing to the slower speed at which the apron is necessarily driven in order to perform the carbonization efficiently. As the capacity of a dryer depends on the amount of moisture in the stock, the following capacities are based on the assumption that the stock has been well hydro-extracted and does not contain more than 60 pounds of water per 100 pounds of dry wool.

CAPACITY IN POUNDS PER DAY OF 10 HOURS

Drying Pounds	Carbonizing Pounds	Width of Apron Feet	Length, Exclusive of Self-Feed		Horsepower
			Feet	Inches	
4,000	2,000	4	37	6	11
6,000	3,000	6	39	1	12
9,000	4,500	9	39	1	14

14. Another type of sectional dryer is shown in Fig. 4, the steam coils in this machine being placed over the carrying apron instead of in a compartment at one side. In this case the fans are carried in a horizontal instead of a vertical plane. In operation, the stock is fed on the

carrying apron and passes into the first compartment of the machine, where the air heated by the steam coils *a* is drawn through the wool on the apron *d* by the fan *b*, which also forces it through the wool again, as indicated by the arrows showing the circulation of the heated air. The stock then passes into the second compartment of the dryer, where the heat is reduced and the wool is subjected to the air heated by the steam coils *c* and circulated by the fan b_1. Besides the carrying apron, there is another apron *e*, shown in the illustration, the purpose of which is to keep the stock from being blown off the apron at those points where the current of heated air is passing upwards. This apron and also the carrying apron are made of wire screens, those usually employed in dryers being about $\frac{1}{4}$-inch mesh. The inlet of air in this machine is at *f*, while a current of moisture-laden air finds its exit from the machine at *g*; thus it will be seen that the general direction of the air is against the motion of the stock.

FIG. 4

At *h*, there is a revolving beater for the purpose of opening up the stock before it leaves the machine, thus making it emerge in an open and lofty condition instead of in the more or less

matted condition in which it is received from the washer. Sectional dryers are sometimes built with more than two compartments, although two are sufficient for all ordinary purposes.

HYDRO-EXTRACTORS

15. Hydro-extractors, already referred to in Art. 12 are not designed to dry the stock, but are largely used for removing the bulk of water from wet wool, cloth, yarn, etc., and are indispensable to a dye house or scouring plant. In some mills, the stock is rinsed in a rinsing box instead of in the last bowl of the scouring machine, in which case it is necessary to run the stock through an extractor before drying or sending it to the dye house, unless the rinsing box is provided with a pair of squeeze rolls. In some cases when the stock is fed to the dryer directly from the squeeze rolls of the washer, an extractor is not necessary; but although the squeeze rolls remove a considerable amount of moisture, the production of the dryer is reduced, owing to the excessive amount of moisture that must be dried out and that could be much more rapidly removed by extracting. Stock that is run through a hydro-extractor contains from 6 to 12 per cent. less moisture than stock from the squeeze rolls of the washer. This represents a considerable saving of time and heat in drying the stock, thus making the hydro-extractor an economical machine for the mill.

Hydro-extractors are also used for extracting the acid solution used in carbonizing, before subjecting to heat; in fact, any place where it is desirable to remove rapidly a large percentage of moisture in saturated raw stock, yarn, or cloth, the hydro-extractor is an economical machine. When used for acid work, the basket of an extractor should be galvanized or lead-lined so that the acid will not attack and destroy it.

SELF-BALANCING EXTRACTOR

16. This type of hydro-extractor, shown in Fig. 5, consists of a wrought-iron casing *a* supported by standards *b*. These standards are cupped out to receive the ball-shaped

heads of the supporting rods *c*, which lead down to the lower flange of the casing and are there attached by similar ball-and-socket joints. The necessary adjustments for leveling the outer casing and parts carried by it are secured by means of turnbuckles on the supporting rods. These may be securely fastened by means of check-nuts.

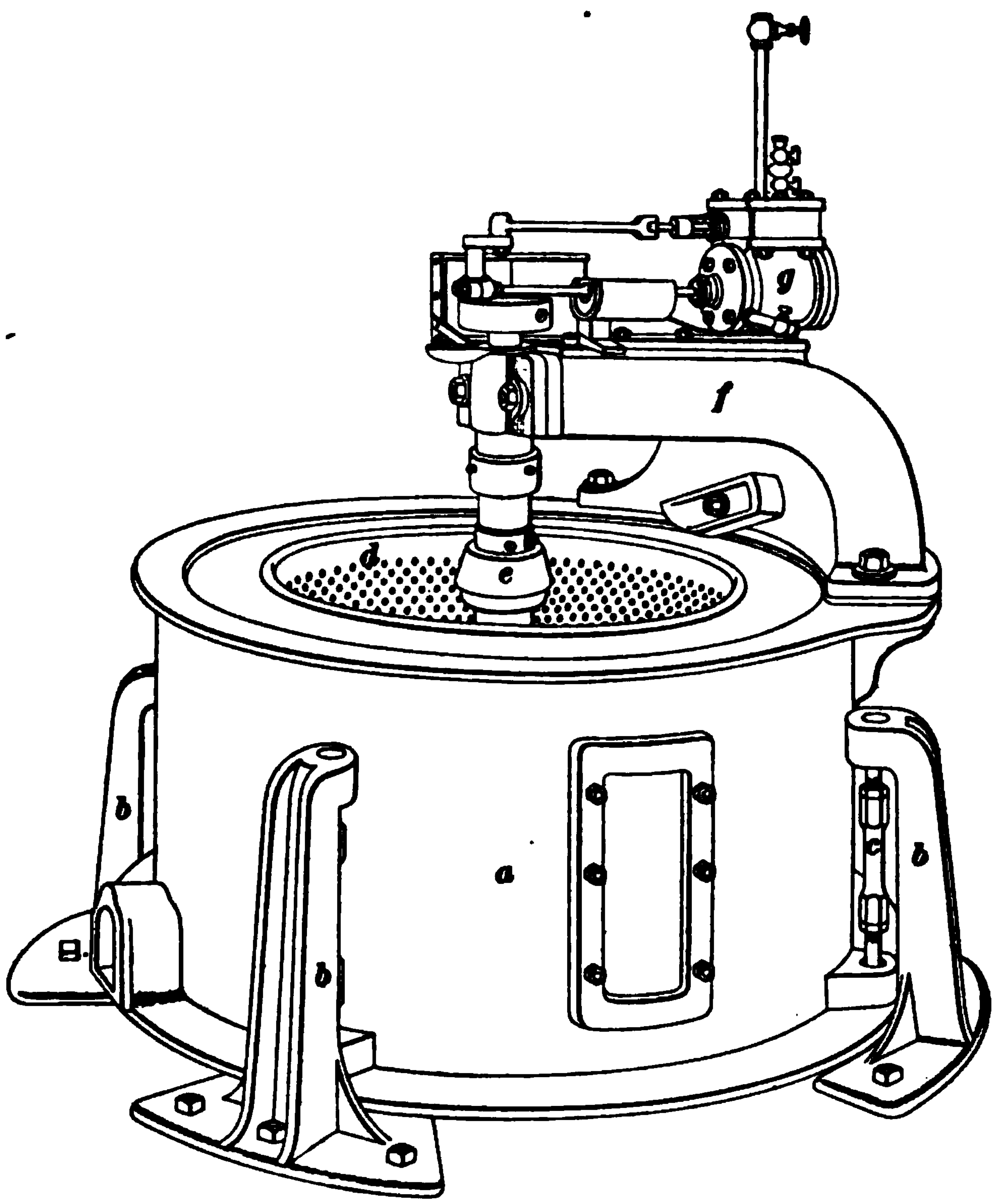


FIG. 5

The basket *d* of the extractor is made of perforated metal and is built on a central shaft *e* supported at the top by a housing *f* that rises from one side of the outer casing and extends to the center of the machine. The basket is driven by a small steam engine *g* carried on the housing. The machine therefore requires no belting or shafting of any

kind. The engine is attached directly to the shaft of the basket, and the loaded basket serves as a flywheel when the extractor is in operation. This allows the basket to be started very quickly, as no time is lost by belt slipping, etc., and the machine is at full speed in a few seconds.

In operation, stock saturated with water or other liquids is placed in the perforated basket and the steam admitted to the engine. In a few seconds, the basket is revolving at a high rate of speed and the water is being driven through the perforated sides of the basket by the centrifugal force generated by the rapid rotation. The water removed from the basket is retained by the outer casing, from which it passes off as waste water through a suitable outlet in the casing. In a few moments the bulk of the water contained in the stock is removed and the machine may then be stopped, emptied, and another lot placed in the basket. The extractor should not be allowed to run too long, however, in an attempt to remove too much moisture, or the stock will be rolled and matted. The vibration of the basket is a feature of all hydro-extractors that it is impossible to remedy and is due to the unequal loading of the heavy, wet material. In this extractor, however, the difficulties that would ordinarily arise because of this unavoidable vibration are overcome by carrying the entire machine on movable supports. The machine is thus entirely suspended and is free to vibrate in any direction, if unevenly loaded, thus preserving the parts in their original relation to one another without imparting any of the shaking to the floor or the building in which it is located. This manner of balancing an extractor is far superior to the old way of allowing the basket to wabble, or gyrate, inside the outer casing, which remained stationary, thus requiring a greater space between the basket and casing and necessitating a larger machine for the same capacity. The self-balancing hydro-extractor is made in various sizes, with baskets from 30 to 54 inches in diameter. The speeds at which they run vary from 1,000 revolutions per minute for a 30-inch, to 850 or 900 revolutions per minute for a 54-inch, basket.

WESTON HYDRO-EXTRACTOR

17. While this machine is not of the self-balancing type, but instead has a gyrating basket, many of them are in use and give excellent satisfaction. One advantage of this type is that it is very easy to load and unload, as there is neither housing nor shaft in the way, the entire top of the machine being open and clear. This fact renders the capacity of the machine larger than that of a self-balancing extractor.

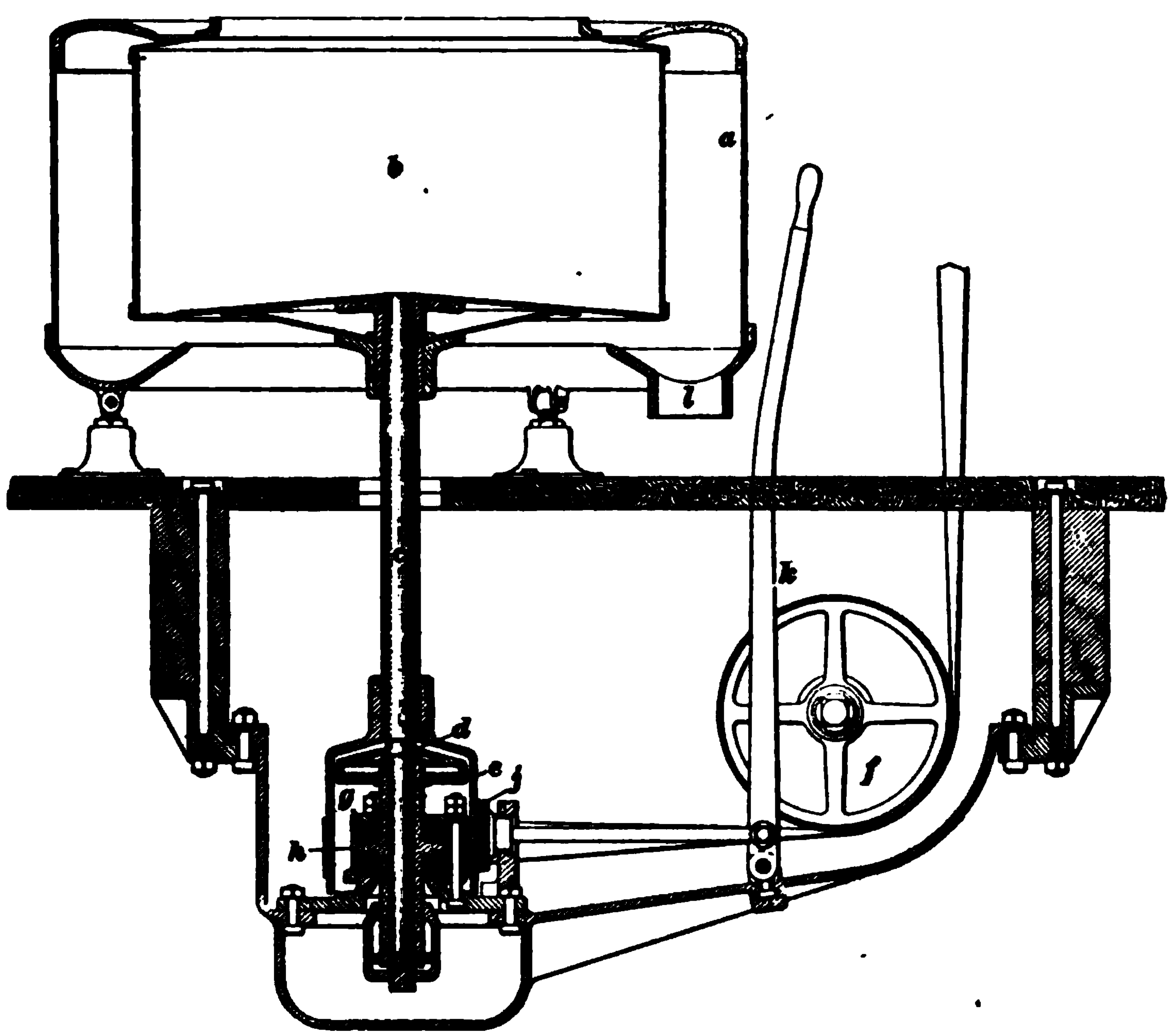


FIG. 6

The machine shown in section in Fig. 6, consists of an outer casing *a* enclosing a perforated basket *b*, which is fastened to a spindle *c* and rotates on the pivot *d*. A pulley *e* is attached to the lower end of the spindle, motion being imparted to the basket by means of a belt passing around this pulley, to which it is guided from a driving shaft by means of two guide pulleys, the one shown being marked *f*.

In order to reduce the vibration and at the same time furnish a certain freedom of motion, the pivot box is supported by rubber cushions *g* carried in a gland *h*. That the machine may be stopped quickly, a brake shoe *j* is arranged to be pressed against the pulley *e* by means of a brake lever *k*. The working parts of the machine are all enclosed in a water-tight, cast-iron trough, or casing, which is bolted to the floor under the extractor; but where this machine is to be erected in basements they are carried in a bedplate set on masonwork.

In operation, the stock to be extracted is placed in the basket *b*, which if unevenly loaded gyrates within the casing *a* until a speed is attained that makes it assume an upright position. The water thrown from the stock is retained by the casing and finds an exit through the outlet at *l*.

BURR PICKING

INTRODUCTION

1. Objects.—Burr picking, or burring, is the first operation through which the wool passes after it has been scoured and dried, except in some cases where it is run through a duster immediately after the drying. When this is done, it is more for the purpose of making the stock open and lofty, so as to facilitate the work of the burr picker, than for the sake of the small amount of dust that is removed. The primary object of burr picking is to remove all the burrs and vegetable matter possible before the stock is passed to the carding machines. Under the head of burrs, various particles of vegetable matter that become attached to the fleece during the life of the sheep are included, although a burr is really a vegetable seed or husk covered with sharp spines, or prickles. Besides actual burrs, the wool often contains twigs, straws, chaff, etc., which, together with finely divided vegetable matter, as crumbled leaves and organic dust, is commonly known as **shives.**

The nature of the burrs found in wool varies greatly with the locality in which the wool is grown. Probably the worst wools in this respect are those coming from South America, notably from Buenos Ayres and grown in the valley of the Rio de la Plata. These wools are infested with a spiral-shaped burr from ½ inch to 2 inches in length, and curled up somewhat like a snail's shell. They are extremely difficult to remove, since they cling with great tenacity to the wool and often are broken into small pieces before losing their hold on the fibers. These are the worst burrs known;

other wools contain in comparison but few burrs and those generally of a kind much more easily removed. The burrs in this class of wool are often called **mestizo burrs,** this name being given on account of the mixed blood of the sheep of that locality.

2. If the burrs are not removed from the wool they are broken into innumerable small particles during the operation of carding, which, remaining in the roving, make hard bunches that cause the yarn to spin unevenly and to have an irregular, rough appearance, which is characterized as **twitty.** Small particles of vegetable matter thus passing through all of the manufacturing processes and occurring in the cloth are known under various terms; as, **specks, motes, burls,** etc. These must be picked out by hand; and in some cases this causes bad holes to be made in the cloth, which must be mended. Vegetable matter will not absorb dye stuffs in the same proportion as wool fibers; consequently, it is seen on the surface of piece-dyed cloths as specks of a lighter color. Burrs in the wool are also a great detriment to the cards, as they tend to dull, bend, and otherwise injure the card clothing and also choke up the card so that stripping, or cleaning, is necessitated much oftener than would otherwise be required.

From what has been said, it will be seen that burrs are matted with the fibers and must be torn from them with considerable force, thus necessitating the employment of a burr picker; in fact, they sometimes cling so tenaciously that the burr picker removes a considerable amount of wool with the burrs. Another object of the burr picker, although of a secondary nature, is to open the wool and leave it in a more lofty condition for the carding machines. This saves a great deal of unnecessary wear and tear on the cards, which would otherwise be strained in opening out bunches of wool that were matted.

TYPES OF BURR PICKERS

PARKHURST BURR PICKER

3. A very effective machine for removing the burrs from wool, known as the improved **Parkhurst burr picker,** is shown in Figs. 1 and 2; Fig. 3 illustrates the working parts. The construction and operation of this machine are such as to have the greatest cleaning effect on the wool with the least possible damage to the fiber. The machine is of solid construction, the framework being made of iron, with the exception of a few minor parts, which, as shown in Fig. 3, are constructed of wood. The greatest care is taken to have all working parts firmly adjusted and free running, since the high speed necessary in a burr picker, together with the large number of parts in motion, render it a machine requiring a considerable amount of power for driving purposes.

4. Construction.—The stock is fed to the machine on an ordinary form of slatted feed-apron *a* that runs on hardwood rolls, the first roll being provided with a screw adjustment by means of which it can be drawn back and the apron tightened, should it become slack through stretching or wear. The feed-rolls *b* are fitted with steel cockspur teeth, so that large burrs are not broken into minute particles, but the stock is held loosely and is not injured while the picker cylinder opens it out. The cockspur teeth are made separately and are securely fastened in grooves cut around the feed-rolls. The rows of teeth are about 1 inch apart and the teeth of the upper roll pass between those of the lower roll. The teeth of each roll being curved back from the direction in which the roll rotates, the stock is held firmly while at the same time the feed-rolls do not become wound and choked with stock, as is liable to occur with rolls covered with

Fig. 1

FIG. 2

the teeth in the burr cylinders and is thus securely held, while the burrs remaining more or less on the surface are knocked out by the blades of the burr guards, which are set close to the surfaces of the burr cylinders. Care should be taken, however, that there is no contact between the burr guards and cylinders, as the latter would be ruined. The wool is removed from the burr cylinders by the brush *f*, which consists of four wooden cross-bars set with stiff bristles from 1¼ to 2 inches in length, and supported by spiders fastened to a central shaft. The brush delivers the wool to the beater *g* by means of the current of air that it produces.

6. The beater is a square, box-like drum built up from a central shaft and having four blades attached; its object is to beat out such loose material as dust, shives, etc., which will then fall through the screen g_1 placed under the beater. Some machines have two beaters, as shown in Figs. 1 and 2; others only one, as shown at *g*, Fig. 3; while sometimes they are entirely dispensed with. The beaters are placed at the spout, where the wool leaves the machine, and, as the stock at this point is opened out nicely, they easily remove a large amount of finely divided dirt that has escaped the previous operations and that would otherwise pass through the machine with the wool.

A large blower, or fan, *h* is placed on the floor at the rear of the machine and creates a draft through the screen *c*, which is placed opposite the feed-rolls, the object being to remove light dirt and dust from the wool and discharge it outside of the mill through suitable pipes. The blower consists of a cylindrical iron box in which a six-bladed fan is mounted on suitable bearings. One important advantage of locating the blower for a burr picker on the floor and at the rear of the machine, is that an under draft is secured, which is an important factor in cleaning stock. The current of air in this case does not hinder the fall of the heavy particles of dirt shaken from the stock by the picker cylinder but rather assists it, and such dirt is therefore readily deposited beneath the screen, or grate, c_1, which is placed under the

picking cylinder, while the lighter dust is drawn away through the screen c_3 by the blower.

7. The top of this machine is so arranged that it swings back, carrying the brush with it. This is a great advantage in cleaning the machine, as it exposes the burr cylinders and guards so that they may be easily cleaned and made ready for the next lot of wool. Fig. 1 shows the bonnet f_1 laid back on the feed-apron and the burr cylinders exposed. The machine is provided with hinged doors, located under the feed-apron, for cleaning the space under the picking cylinder, which can be quickly cleaned between lots, as the doors can be opened without removing screws or bolts. Sliding brushes are placed under the screens beneath the beaters for the purpose of cleaning them. There is also a brush for cleaning the screen at the rear of the picker cylinder, which if clogged hinders the draft of the blower. This screen sometimes becomes coated with a gummy substance; if greasy wool is used it must then be taken out and washed with soda, potash, or any compound that will cut the grease. There are also small handholes g_2 for cleaning the spaces under the beater screens and for removing the fine dirt and shives that fall through them.

8. Driving.—The driving of the various parts of the burr picker will be readily understood by the following description in connection with Figs. 1 and 2: The main shaft of the machine is fitted with tight and loose driving pulleys c_5 and all working parts are belted from the main shaft. Only one belt is required to drive the machine, except on the large size (48-inch width) where a double drive is used, that is, a tight pulley on each side of the machine driven from a countershaft on which tight and loose pulleys are arranged. The front burr cylinder is driven by a 12-inch pulley c_4 on the picker shaft, which drives a 16-inch pulley d_4 on the front burr-cylinder shaft. This drive is shown in Fig. 2. The rear burr cylinder is driven on the other side of the machine, as shown in Fig. 1, by a 9½-inch pulley c_7 on the main shaft, which drives a 16-inch pulley e_8

on the shaft of the rear burr cylinder. The blower is driven by a 17-inch pulley c_8 on the main shaft, which drives a 6-inch pulley h_3 on the blower shaft, also shown in Fig. 1.

The two burr guards are driven by a 17-inch pulley c_8 on the main shaft, which drives two pulleys e_4, d_5 on the burr-guard shafts, the pulley on the front burr-guard shaft being 4 inches in diameter and the pulley on the rear burr-guard shaft being 5 inches in diameter; these pulleys are shown in Fig. 2. A driving pulley h_2, 10 inches in diameter, on the blower shaft drives an 8-inch pulley g_3 on the first beater shaft with a crossed belt, as shown in Fig. 1, and on the opposite side of the machine the two beaters are connected by a belt and 8-inch pulleys g_4, g_5, as shown in Fig. 2. A 10-inch

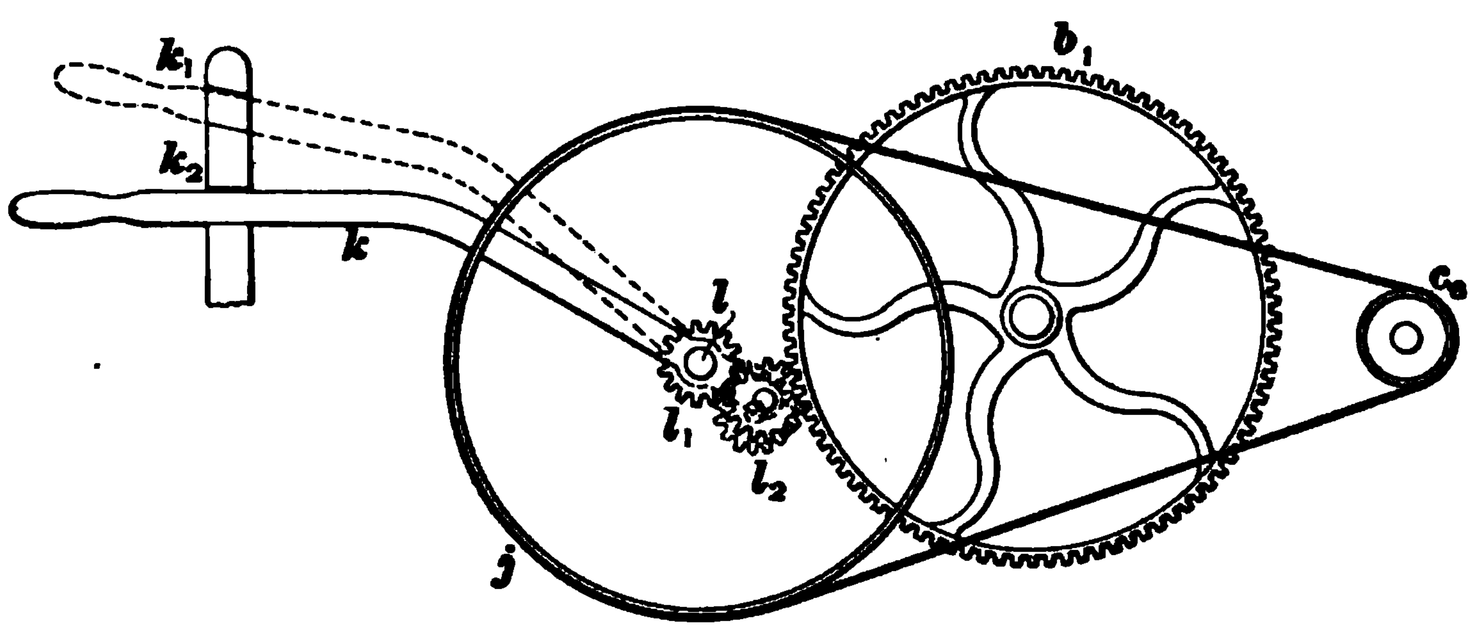


FIG. 4

pulley h_1 on the blower shaft drives a 7-inch pulley f_2 on the shaft of the brush with a crossed belt. The driving of the feed-rolls is shown in Fig. 1, and is as follows: A $4\frac{1}{2}$-inch pulley c_6 on the picker-cylinder shaft drives a pulley j, 24 inches in diameter, on a stud l, see Fig. 4. A pinion gear l_1 with 15 teeth, fastened to the pulley j, drives an intermediate gear l_2, which in turn meshes with a 150-tooth gear b_1 fastened to the bottom feed-roll shaft. The top and bottom feed-rolls are coupled together with 15-tooth gears b_2 and b_3 on the opposite side of the machine, as shown in Fig. 2, the gear on the bottom feed-roll shaft also driving a 17-tooth intermediate a_2 which drives a 17-tooth gear a_3 on the front apron-roll shaft, thus driving the feed-apron.

9. Device for Stopping Feed.—There is a device on this machine for stopping the feed-rolls and apron without stopping the whole machine; this allows the operator to stop the delivery of wool to the picking cylinder immediately when anything wrong is seen with the working of the machine. The mechanism is simple and effective. A lever marked k, Fig. 4, is pivoted on the stud l. The pinion gear l_1 is loose on this stud, as is also the pulley j. The gear l_2 is loose on a stud fixed at the extremity of the lever k. Thus, when the lever is raised, as shown by the dotted lines, and held in that position by the slot at k_1, the gear l_2 will be withdrawn from contact with the gear b_1; this stops all motion of the feed-rolls and apron. The slots k_2, k_1 are cut in a piece of steel bolted to the side of the feed-trough and hold the lever firm when the pinion is in or out of contact with the gear b_1.

10. Operation.—In operation, the stock is spread evenly on the feed-apron a, Fig. 3, either by hand or by an automatic or self-feed, and is carried forwards to the pair of cock-spur feed-rolls b. The wool is held by the feed-rolls and is combed and opened out by the rotating picking cylinder c, which revolves upwards past the feed-rolls. The picking cylinder carries the wool to the burr cylinders d, e, and the stock is deposited in the spaces between the rows of teeth on the burr cylinders, while the burrs lie on the surface and are knocked off into the burr box d_2 by the burr guards. The passage of the material from the feed-rolls to the picking cylinder and from the picking cylinder to the burr cylinders, the cylinders being in rapid rotation, results in the wool being beaten, drawn, and opened, the burrs gradually being thrown to the outside and ultimately hanging loosely from the burr cylinders from which they are easily knocked by the burr guards.

11. It may be said with regard to this machine that the burr guard e_1 does not throw the burrs clear of the machine, as does the guard d_1, but instead throws them either on to the first burr cylinder, where they then come under the action of d_1, or else into the picking cylinder, where, unless they fall

through the grate, they are carried around until again brought under the action of the burr cylinders.

12. All dirt that is knocked from the wool by the picking cylinder *c*, if heavy, falls through the grate, or screen, c_1 into the space underneath, whence it can be removed periodically by opening a hinged door underneath the feed-apron of the machine. If the dirt is light, as dust and shives always are, it is removed by the blower *h* through the screen c_2 and blown outside of the mill through a suitable pipe. The wool fiber is removed from the burr cylinders *d*, *e* by the rotating brush *f* and passed along by the current of air generated by the brush to the beater *g*, which revolves at a rapid rate and beats much loose matter that has escaped the previous operations through the screen g_1 into the space underneath, whence it may be removed through the handhole g_2.

Two beaters are of great value for fine stock and also for knitting stock, but for ordinary wool one of them is sometimes removed. Frequently when long-stapled stock, such as carpet and other coarse wool, is being run through the burr picker, both beaters are removed. After passing through the beaters, the stock is conveyed by a suitable pipe to the gauze room, where it is ready for the next process.

13. In Fig. 3, a steel straightedge, or knife, is placed at f_1 to prevent the stock from winding around the brush and also to keep the bristles of the brush clean. At d_2 a similar knife is placed to prevent the burrs that are knocked out by the burr guard d_1 from flying back into the burr cylinder *d*. A guard e_2 is placed over the burr guard e_1 in order to prevent the wool removed from the burr cylinder *d* by the rotating brush from falling on the burr guard e_1 and being thrown on the picking cylinder *c*.

14. Burr Cylinders.—Most mills are equipped with two sets of burr cylinders—a coarse set for coarse stock, and a fine set for finer stock. The necessity for this is that if a cylinder with coarse teeth on it is used for fine stock, much of the wool will be pulled from it and cast out. Good burr picking removes the burrs and as little of the stock with

it as possible. On the other hand, if cylinders covered with fine set teeth are used for coarse stock, the wool will not penetrate into the spaces between the steel rings of teeth, and there is danger of the fiber being broken and of a good deal of wool being knocked into the burr box by the guards.

The ordinary type of burr cylinder is made of iron, and after being trued has a continuous spiral, or helical, groove cut around it. A specially prepared toothed wire is wound around the cylinder in the groove cut on it and the spaces between the rows of wire carefully staked in order to hold the wire firm. The roll is then ground to a true surface. The burr wire used for the burr rolls of pickers has a flat top; in Fig. 5 two kinds are shown, one with a long and one with a short top. The short-top wire is suitable for fine, short wool, while the long-top wire is especially adapted for

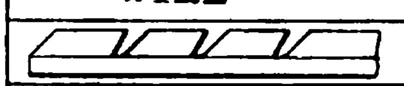
WIRE	SIZE	STYLE	TH'DS PER 1"
	2	Long Top	5 - 8
	3	" "	8 - 12
	2	Short "	5 - 8
	3	" "	8 - 12

FIG. 5

longer and coarser wool. This wire is drawn from fine steel and is made with a rib, or flange, at the base, so that when staked into the cylinder the metal will crowd, or overlap, the base of the wire, thus holding it firm. The teeth are all cut in the wire before it is wound on the cylinder. Garnett wire, as this wire is commonly called, takes its name from that of the inventor, who first used it on machines for tearing up rags in the preparation of shoddy and mungo. Old burr rolls, and other cylinders that are covered with burr, or similar, wire may be recovered when damaged or worn out.

This type is known as the wire-wound roll, but in the Parkhurst picker a special type known as the steel-ring burr cylinder is used. The teeth for this roll are cut on a solid steel ring with a hole of the exact diameter to be slipped on a smooth iron roll. The rings of teeth are kept apart by

being alternated with packing rings of the proper thickness that have no teeth, the whole being firmly secured. The advantage of this roll is that it can be repaired without rewinding, as is necessary with the wire-wound rolls.

15. Speeds.—With regard to the speeds of the various working parts of the burr picker, it may be said that high speeds are very necessary in order to accomplish the complete removal of the burrs. The following list gives the speeds of the various parts of the Parkhurst picker, and may be figured by the student with the data previously given in regard to the driving of the parts:

Picking cylinder . .	450	revolutions per minute
Front burr cylinder .	337	revolutions per minute
Rear burr cylinder .	267	revolutions per minute
Blower	1,275	revolutions per minute
Beaters	1,593	revolutions per minute
Front burr guard . .	1,912	revolutions per minute
Rear burr guard . .	1,530	revolutions per minute
Brush	1,821	revolutions per minute
Feed-rolls	$8\frac{1}{2}$	revolutions per minute

16. This picker is built in four widths; viz., 24-inch, 30-inch, 40-inch, and 48-inch. The production of the 48-inch machine is from 4,000 to 6,000 pounds per day according to the amount of stock placed on the feed-apron, and also to the number of times the stock is run through the machine, which depends on the amount of burrs in the stock, once being usually sufficient. This burr picker requires from 3 to 10 horsepower, depending on the width of the machine, and should be driven with at least a 5-inch belt.

SARGENT BURR PICKER

17. In Fig. 6, a burr picker known as the **Sargent multiplex burr picker** is shown with a self-feed attached. This machine works on practically the same principle as the Parkhurst picker. The wool is opened by a picking cylinder and is deposited on a pair of burr cylinders covered with

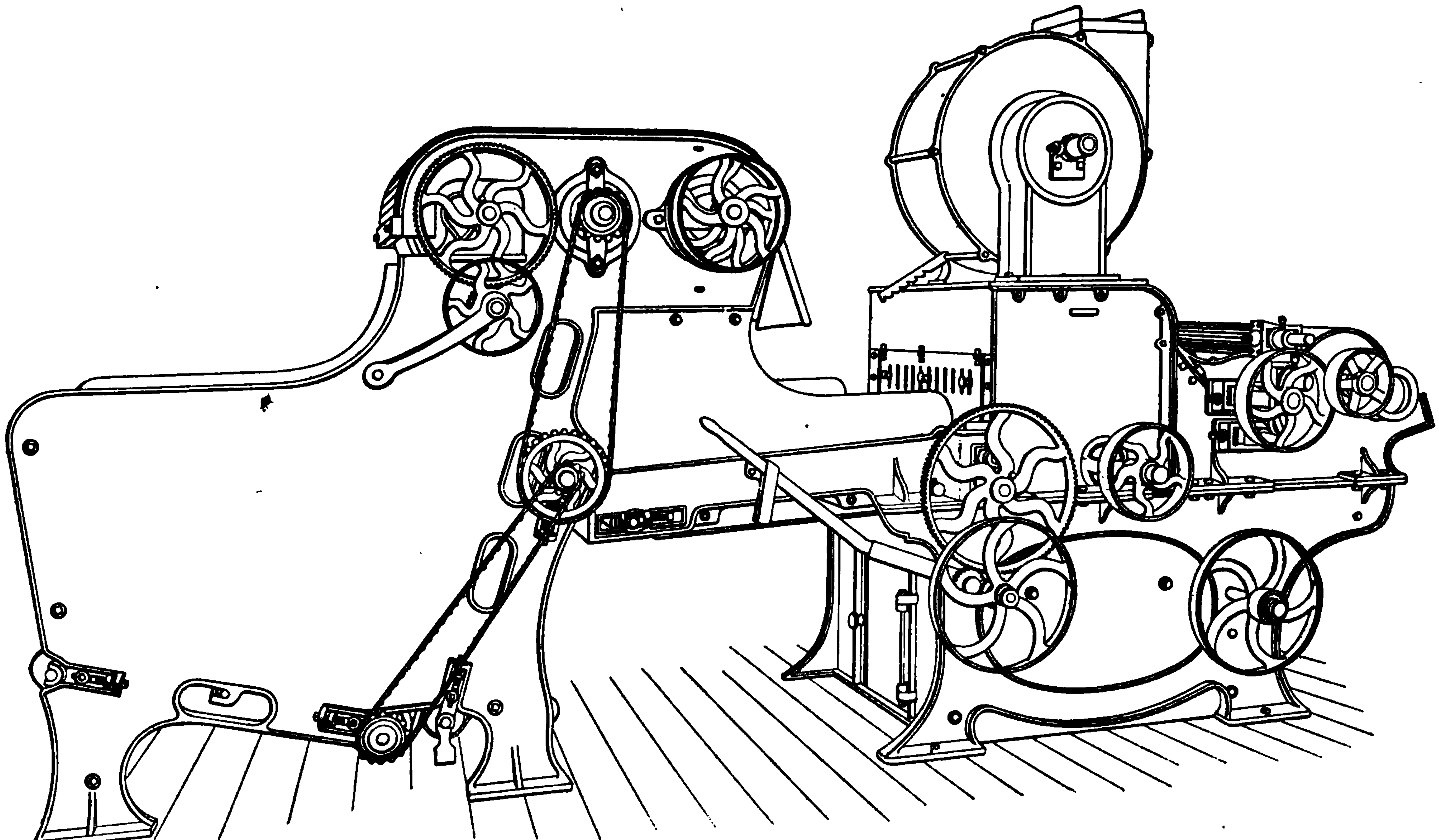


FIG. 6

burr wire, where the burrs are removed by means of burr guards in the usual manner. The machine is constructed, however, somewhat differently from the Parkhurst picker. The burr cylinders and guards are placed opposite the feed-rolls instead of over the picking cylinder. The fan, or blower, is placed on the top of the machine instead of on the floor behind the machine. It removes light dirt and dust from the stock and discharges it outside of the mill by means of a suitable pipe in the usual manner, but as the fan is on the top of the machine, it creates an over draft instead of an under draft through the machine.

The stock is fed on a slatted feed-apron either by hand or by a self-feed. The wool is taken by the feed-rolls and delivered to a picking cylinder similar in construction to that of the Parkhurst picking cylinder, but which runs past the feed-rolls downwards instead of upwards. The stock is subjected to the action of the picking cylinder and the grid, or rack, underneath it, through which drops a large amount of dirt that can be subsequently removed. The wool is then taken by the burr cylinders and sinks into the spaces between the rows of teeth, while the burrs lie on the surfaces of the cylinder and are knocked off by the burr guards. The lower burr guard running in connection with the first burr cylinder throws the burrs on the floor behind the machine, while the upper guard throws the burrs from the upper burr cylinder into a receptacle on the top of the machine. The burr cylinders are stripped by a brush similar to that of the Parkhurst burr picker, and the stock blown to the gauze room by the current of air generated by the rotating brush. The speeds of the different parts of this machine should be about the same as those of corresponding parts of the Parkhurst picker.

The self-feed shown attached to the burr picker illustrated in Fig. 6 is known as the **Sargent low feed.** This self-feed is adapted for burr pickers, cone and carbonizing dusters, mixing pickers, or any similar machine.

SINGLE BURR-CYLINDER PICKER

18. A burr picker with but one burr cylinder instead of two is very popular with mills using wools with few burrs, but in case of very burry stock it is customary to run it through a single burr-cylinder machine several times, so as to be sure that the burrs are all removed, since this machine is not nearly so effective as the double burr-cylinder machines previously described.

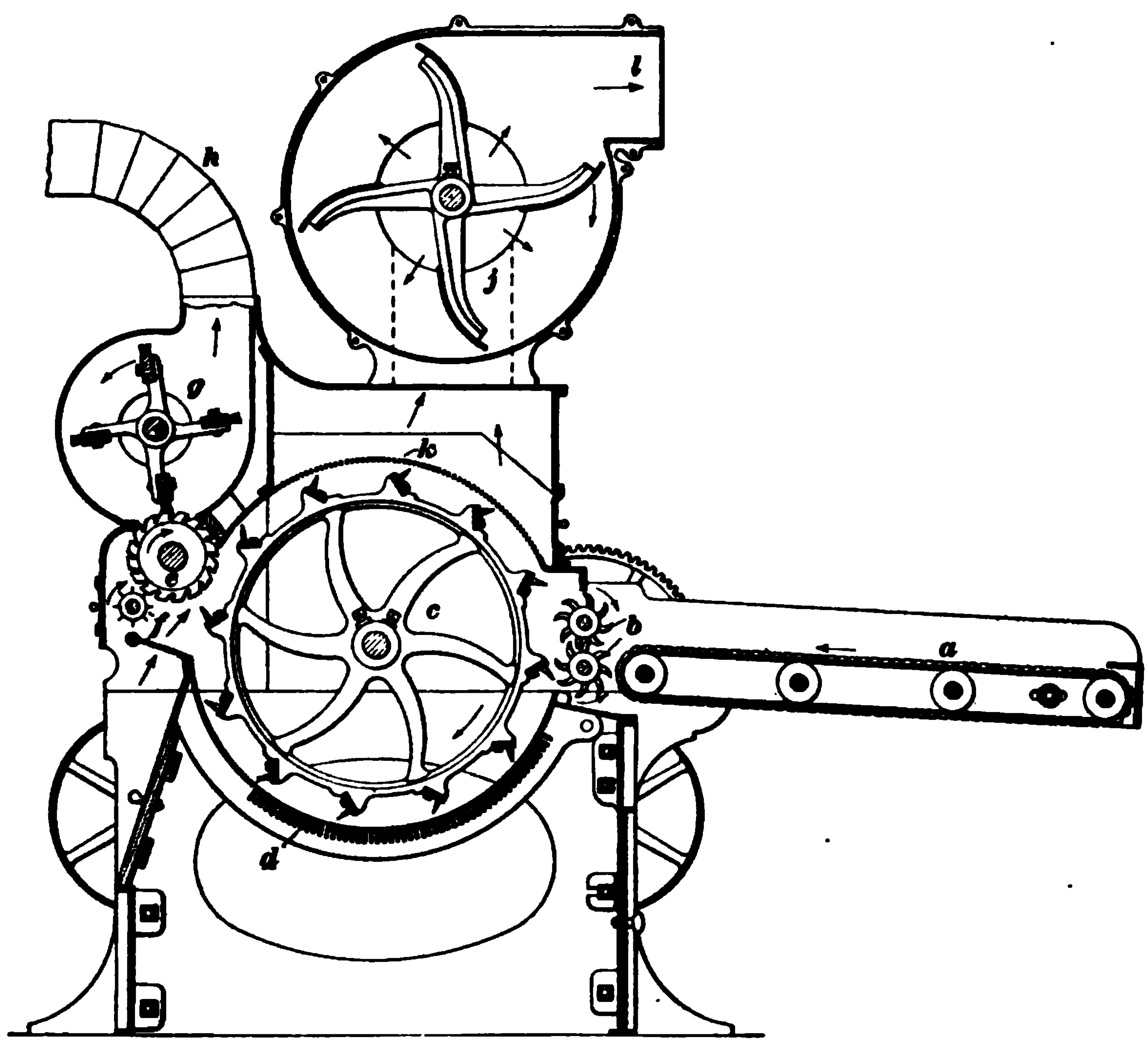


Fig. 7

A section of a single burr-cylinder machine is shown in Fig. 7; its operation is as follows: The stock is fed in the usual manner on a slatted feed-apron *a*, from which it is taken and fed to the machine by the cockspur feed-rolls *b*. The picking cylinder *c* then takes the stock and carries it over the rack *d*, thus shaking out the loose dirt, which drops

through into the lower part of the machine, from which it may be removed. The wool is then deposited on the burr cylinder *e*, where the burrs are removed and cast on to the floor at the rear of the machine by the burr guard *f*. The wool is removed from the burr cylinder by means of a rotating brush *g*, which also generates a current of air for delivering the stock through the pipe *h* to the gauze room. A constant current of air is maintained in the machine by the blower *j*, which draws the dust through the screen *k* (which retains the wool) and conveys it to the outside of the mill through the pipe *l*. The inlets for the air are under the feed-rolls and at the back of the machine under the burr guard.

GODDARD BURR PICKER

19. The **Goddard,** or **Curtis and Marble, burr picker** is favorably known to the trade and is found in some of the best mills. It is shown in Fig. 8 and in section in Fig. 9. The machine is constructed with the same objects in view as those previously described; namely, to remove burrs, shives, dust, and other foreign matter from the wool, and also to open the stock and make it lofty for the cards without breaking or injuring the fiber.

The principle of this machine is somewhat different from the burr pickers previously described, but still the same general features are present; i. e., opening the wool with a picking cylinder and delivering it to burr cylinders, from which it is stripped by a rotating brush, the burrs being removed by burr guards.

20. Construction.—The feed-rolls are set with cockspur teeth, which hold the wool securely while the teeth of the picking cylinder thoroughly open it. The bottom feed-roll is stripped by the picking cylinder, and in order to prevent all chance of the stock winding around the top feed-roll, this roll is driven faster than the bottom roll; thus, the wool is cleaned from the back of the cockspur teeth on the top feed-roll by the points of the teeth on the bottom roll.

The feed-apron and feed-rolls in this machine may be stopped by means of a lever without stopping the rest of the machine, as described in the case of the other burr pickers.

21. The picking cylinder is composed of sixteen cross-bars, which are attached to spiders fastened to the main shaft of the machine. The cross-bars are filled with round-pointed teeth of steel, which are placed staggered, so that at each revolution of the cylinder the teeth cover every sixteenth inch of the width of the machine. Above the picker cylinder is a perforated brass screen fastened to an iron frame and held in place by buttons, so that it can be readily removed for cleaning. This screen has perforations of sufficient size to allow fine dust and dirt to be removed from the wool through it. The screen is removable to give access to the picker cylinder for cleaning or other purposes.

Beneath the picker cylinder is a grate, or grid, made of angular iron bars. This grate is made especially firm and will not bend out of shape; thus, the spaces between the bars of the grate are always the same. The grate is made fine enough so that loss of wool is avoided, but the heavy dirt, shives, etc., are allowed to drop through it. The grate is hinged at the rear and may be lowered in order to clean it and the picking cylinder between different lots of wool.

At the rear of the picking cylinder, two burr cylinders are built up on central shafts with alternate steel-toothed rings and solid packing rings. These burr rolls should be made of the right-sized toothed rings, or burr wire, to suit the class of wool that is being operated on, and should be spaced fine or coarse to suit the same. The burr cylinders in the Curtis and Marble pickers are not of the same size, as they are in the machines previously described, but one is smaller and works over the larger one—running in the opposite direction. The larger burr cylinder is provided with a burr guard that knocks the burrs from the surface of the cylinder. Working in conjunction with this burr guard is a smaller one, which prevents the burrs and other refuse from being carried over on to the brush cover. On this

machine a rotating brush, with six cross-bars filled with bristles, strips the stock from the burr cylinders and delivers it to the gauze room through a suitable spout or pipe.

22. Oilers.—In Fig. 8, a square tank will be seen placed over the spout where the wool leaves the machine. This is a device for oiling the wool as it leaves the picker so that it

Fig. 8

will be ready for carding. This may be attached to the picker when desired. The **oiler** consists of a revolving brush that throws the oil supplied by a tank over the wool as it passes from the picker. Oiling wool by mechanical devices, either at the picker spout or elsewhere, is not generally approved by the trade. Oilers afford an easy means of lubricating

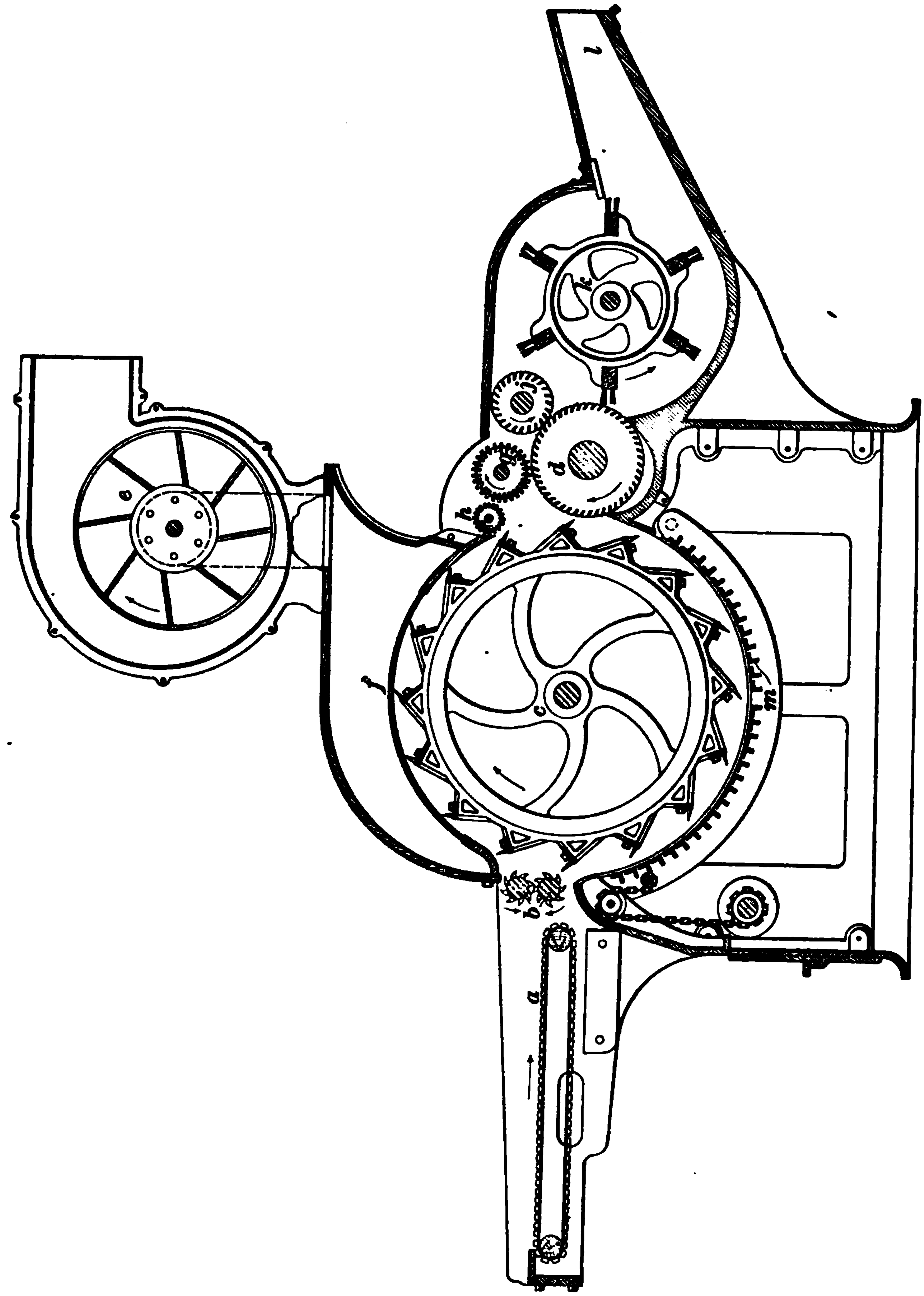


Fig. 9

cheap stock, but are seldom used on fine stock, as will be explained in another Section.

23. Operation.—In operation, the stock is fed to the traveling apron either by hand or by a self-feed. The apron *a*, Fig. 9, carries the wool to the cockspur feed-rolls *b* of the machine, where it is loosely held while being combed and opened out by the picker cylinder *c*. The wool is thus opened out at the start and the burrs and dirt loosened. The picker cylinder revolves upwards past the feed-rolls and carries the wool to the large burr cylinder *d*. The exhaust fan, or blower, *e* on the top of the machine creates a strong draft of air, which removes loose and small particles of dirt through the perforated brass screen *f*, and also lifts the fibers of wool from the picker cylinder, so that they are more readily caught by the teeth of the burr cylinder *d*. This cylinder takes the stock from the picker cylinder, receiving the fibers in the spaces between its toothed rings, while the burrs and other matter being larger than the fibers of wool remain on the surface of the cylinder and are removed by the rapidly revolving burr guard *g*. Working in connection with this burr guard is a smaller roll *h*, which prevents the burrs and refuse from being thrown on to the brush cover. The burrs thrown out by the burr guards are carried downwards by the picker cylinder, and such as do not drop through the grate *m* under the cylinder are carried forwards and thrown into a burr box through an opening beneath the feed-rolls of the machine. A small burr, or cotter, cylinder *j* operates in conjunction with the large burr cylinder, revolving slowly in the opposite direction and opening out cotted lumps of wool. The revolving brush *k* cleans the wool from both burr cylinders and delivers it through the spout *l* to the gauze room.

24. The Goddard picker, as shown in Fig. 8, requires a countershaft. The picking cylinder, fan, and revolving brush are driven direct from the countershaft, as is also the oiler, if used. The other parts of the machine are driven from the

main picker shaft. The following table shows the capacity of the different widths of these machines, the amount of work turned off varying, of course, under different conditions.

Size of Picker Inches	Diameter of Picking Cylinder Inches	Capacity per Day Pounds
24	24	600 to 1,200
30	30	1,200 to 2,400
40	30	1,600 to 3,200
46	36	2,200 to 5,000
48	36	3,000 to 7,000

MANAGEMENT OF BURR PICKERS

25. In regard to the management and proper care of burr pickers, it may be said that one of the most important points is to clean periodically the various parts of the machine. All perforated, or wire, screens, grates, conducting pipes, etc. should be kept clean and clear of dirt and grease. If they are clogged up, they hinder the removal of the dirt from the wool and also reduce the efficiency of the fan, thus weakening the strength of the air-currents through the machine. Screens with small perforations will become completely coated with grease and gummy dirt, and when found in such condition should be immediately taken from the machine and washed with a strong solution of soda. When the gum is thick, a good deal of it can be scraped off before the screen is washed. The spaces under the picking cylinder and under the beaters of a Parkhurst picker should be frequently and regularly cleaned out. On the Parkhurst machine the swing-back bonnet is so arranged that it can be lifted back after the belt has been thrown off from the brush, thus allowing the burr cylinder and interior of the machine to be cleaned.

After a batch of wool has been run through the machine, if much fiber is clinging to the burrs that have been cast out,

the burrs are sometimes run through the machine again in order to obtain all the fiber possible. As a rule, however, this does not pay, not only because of the time required, but also because of the danger, where there are so many burrs, of some of them passing forwards with the wool instead of being thrown out of the machine the second time. As burr pickers run at a high speed, it is essential that all bearings of rapidly rotating parts be oiled at least twice a day; otherwise, there is danger of the journals heating and becoming fast in the bearings. All belts used in connection with a burr picker should be laced, as there is danger of accidents if belt hooks are used, since the belts are in exposed places and it is necessary in many cases for the operator to work in close proximity to them. The brushes of burr pickers wear out rapidly, and they should be set up closer to the burr cylinders from time to time and ultimately replaced.

26. Setting.—In regard to the setting of the working parts of a burr picker, it may be stated that this depends largely on the character of the stock being run through the picker. For a coarse, long-staple wool, the burr cylinders may be set farther from the picker cylinder than for a finer and shorter wool, when they may be set up as close as possible without any contact. The burr guards should be set as close as possible to the burr cylinders without knocking out the wool as well as the burrs. If set too far from the burr cylinders, many burrs will escape them; while if set too near, they will pull the wool from the cylinder. Great care should be taken not to allow either the picking cylinder or the burr guards to touch the burr cylinders, since, if this is the case, the burr cylinders will be damaged and very soon ruined. The picking cylinder does not require to run very close to the burr cylinders, since the centrifugal force, due to its rapid rotation, will throw the stock from the picking cylinder into the burr cylinders. The brush should be set to strike into the burr cylinders slightly, so as to clear them thoroughly of wool. Care should be taken, however, that the brush does not strike the burr roll with any great force, as this will quickly wear

out the brush and necessitate its being replaced. Again, if set too close, there is a liability of the stock being carried around the brush.

27. Gauze Room.—The stock from a burr picker is delivered by the current of air generated by the brush to a gauze room. This is usually a wooden compartment provided with openings covered with wire screening, or gauze. The stock is blown from the burr picker to this room, the object of the gauze-covered openings being to let out the surplus air, but to retain the wool. Such machines as burr and mixing pickers, which deliver the stock by means of a strong current of air, require some such room in which to deposit the wool in order to collect it within a small space. The gauze room should be made large enough to accommodate a batch of wool easily, and should have a door of sufficient size to permit the easy removal of the cleaned stock. The door should have strong and suitable fastenings, and the openings in the room, which are covered with wire gauze to allow the egress of air, should be of sufficient area so that the efficiency of the current of air from the picker will not be impaired. If the gauze room is to be used for wool that is oiled in the burr picker, or for receiving the stock from a mixing picker, the floor of the room should be covered with tin, or preferably zinc, to prevent the oil from soaking into the floor. Care should be taken to prevent fire in a burr picker, or any similar machine that depends on currents of air for its operation, as nothing causes a fire to spread so quickly as an air-current.

28. Calculations.—The only calculations required in connection with a burr picker are those used in finding the speeds of the various parts, which may be readily done by means of the instruction previously given in regard to speed calculations.

CARBONIZING

INTRODUCTION

1. There are two methods in general use for removing the vegetable matter with which all wools are more or less impregnated, namely, the *mechanical* and the *chemical processes*. The **mechanical process,** which consists in the removal of the burrs and other vegetable matter by means of some form of machine, such as is described in *Burr Picking*, has already been dealt with. The **extracting,** or, as it is commonly called, the **carbonizing process,** removes the vegetable matter by means of chemical action whereby the structure of the vegetable matter is destroyed so that it may be easily shaken or dusted from the wool. Wools filled with small burrs, shives, etc., are cleaned much more easily and cheaply by extraction than by burr picking. Wools that have only comparatively few burrs adhering to them are usually run through a burr picker only, while wools that are quite burry are sometimes burr-picked to remove the larger burrs and afterwards carbonized to destroy all the minute burrs and other vegetable matter, as shives, dust, chaff, etc. that may have escaped the burr picker.

The carbonizing process is now becoming very common and is largely replacing the use of burr pickers, although it may be said to be more of a European than an American practice. Where wools are mixed with a large amount of fine chaff and straw, carbonizing, or extracting, is indispensable for their complete removal. In some mills, it is the custom to throw aside the most burry portions of the

fleece during sorting and carbonize these portions alone, the rest of the fleece simply being run through a burr picker.

2. The principle of carbonization depends on the action of certain chemicals that will destroy the vegetable matter, but will not injure the wool if the process is properly performed. It is evident that alkaline chemicals are not suitable for carbonizing purposes, since they readily destroy the wool fiber without injuring the vegetable matter. A 2° Baumé (hydrometer) solution of caustic soda will dissolve wool completely if boiled, but it will not affect burrs or even cotton fibers. Acids are, however, particularly adapted for carbonizing, since, if not too strong, there is no injurious effect on the wool, but even a dilute solution will effectually destroy burrs, chaff, cotton, or any other vegetable material. Besides acids, several other substances are used for carbonization; the principal agents in use, however, are sulphuric acid (oil of vitriol), hydrochloric acid (muriatic acid), aluminum chloride, magnesium chloride.

CARBONIZING PROCESSES

SULPHURIC-ACID PROCESS

3. Commercial sulphuric acid, or oil of vitriol, contains varying amounts of water and also other impurities, notably arsenic, iron, lead, sulphur dioxide, etc. In addition, the acid is often discolored by organic dust that has been charred by the action of the liquid. The commercial product, however, is usually pure enough to meet the requirements of carbonizing. In using acid on wool, care should be taken to have the solution weak so that the fiber of the wool will not be injured in any way; for though acids have no appreciable effect on the fiber when dilute, yet if they are strong and any heat is applied, a weakening of the fiber will result, and the stock will have a harsh feeling and a yellow color.

A 1° Baumé solution of sulphuric acid would be sufficient to destroy the smaller particles of vegetable matter in wool,

but for effectually carbonizing large burrs, etc. a stronger solution is found to be necessary in actual practice. The strength of the solution should vary from 2° to 6° according to the coarseness of the stock that is being treated and the number of burrs that it contains. Stock that is naturally tender should be carbonized with as weak a solution as possible, while stronger stock may be treated with a stronger solution. In actual practice it is found that a strength of 4° or 4½° Baumé is about right for wool carbonizing solutions in the majority of cases. In diluting acid with water, the acid should always be poured into the water in a thin stream; water should never be poured into strong acid, since a large amount of heat is generated when the acid and water unite, and if a large quantity of acid is present the solution is liable to explode and cause terrible burns if it comes in contact with the workman. Care should be taken also to stir thoroughly the liquor with a pole, as otherwise the acid, being heavier than the water, will settle to the bottom of the tank and the solution, when tested with the hydrometer, will indicate a weaker solution than is actually present. Again, if the liquor is not well mixed, some of the wool is liable to be injured by the action of that part of the liquor where the acid is too strong, while other portions of the stock will not have the burrs effectually carbonized because of their being in contact with only a very weak solution.

METHOD EMPLOYED

4. The operation of carbonizing with sulphuric acid consists of steeping the wool in the dilute sulphuric-acid solution in large wooden tanks. The length of time that the stock is immersed in the acid solution depends on the strength of the acid, which in turn should be governed by the character of the fiber. The strength of the acid solution most commonly used is about 4° or 4½° Baumé, and an immersion of 40 minutes in a solution of this strength is generally sufficient for the most burry stock. The wool should be kept under the solution while it is in the acid tank, as if portions

of it are exposed to the air the fibers thus exposed are considerably weakened, owing to the concentration of the acid on them by evaporation of the water. It does not harm the wool to any appreciable degree to stay in the acid solution for some time, provided that the acid is not too strong and the stock is completely submerged. Although it is desirable to have the stock thoroughly saturated with the acid solution, no attempt should be made to pole the stock around in the soaking tank, as the benefit derived is not great enough to compensate for the danger of felting the stock.

5. When the wool is thoroughly saturated with the acid solution it is taken out and the moisture partly removed in a hydro-extractor. The basket of the hydro-extractor should be galvanized or made acid-proof in some manner if used for carbonizing work; otherwise, the acid will attack and destroy it. The liquor driven out of the wool in the hydro-extractor should be allowed to run into a tank, from which it can be pumped back into the soaking tubs and used over again. The excess of acid may be removed before drying by means of a pair of squeeze rolls instead of a hydro-extractor, if so desired. The wool is now dried at a temperature of from 160° to 165° F. in an ordinary hot-air dryer, after which it is run through a second dryer and subjected to a temperature of from 200° to 230° F. A temperature of 210° F. in the second dryer is usually about right for wool that has been properly treated with acid. When wool is dried in this manner, it usually occupies about 20 minutes in running through each dryer. A two-compartment dryer is more convenient than two single dryers for drying wool after acid treatment, the temperature in the first compartment being kept at about 165° F. and in the second at about 210° F. The temperature for drying is sometimes made as high as 250° F., but this does not act so mildly on the wool, and is liable to make the fiber of fine wool tender and of a yellow color. Instead of using two single dryers or a two-compartment dryer, as explained above, some mills have a room where the stock can be subjected to the high

temperature after being dried in an ordinary dryer. This method is inconvenient, however, as the stock has to be spread on racks by hand and removed in the same way—a laborious operation as compared with the continuous progress of the stock in a machine dryer.

The temperature in drying must be raised to at least 180° F. or carbonization will not take place. It is always best first to dry the wool, as previously explained, at a somewhat lower temperature and then increase the heat for a short period in order to complete the carbonization. The wool is sometimes dried in an apron dryer with an attachment of crush rolls for pulverizing the charred vegetable matter, in order that it may be more easily removed by the *carbonizing duster* through which the stock is passed after being dried. This machine, which will be explained later, is generally equipped with a series of crushing rolls for crushing the carbonized vegetable matter, as well as means for dusting the crushed matter from the stock. For drying acid-treated stock, it is necessary that the aprons and other metal work of the dryer that are in contact with the stock shall be heavily galvanized, in order to prevent the acid from attacking and destroying them. In order to obtain the best results, the stock should not be exposed to the air for any length of time between acid treatment and drying.

The action of the acid during the drying process—for this is when carbonizing really takes place—is as follows: As the moisture is evaporated, the acid, which has a great avidity for water, attacks the burrs and other vegetable matter, which naturally hold the moisture longer, and extracts it from them, in so doing changing the nature of their structure and converting them into particles of carbon, which crumble to the touch. If the wool is examined carefully, it will be seen that the burrs and other vegetable matter, although they have not lost their form, are in a very brittle state and on being squeezed, or crushed, crumble to a fine dust or powder. When the wool has been dried, it is passed between a series of heavy crush rolls and the carbonized vegetable matter is pulverized and easily shaken or beaten out. The wool is

then immediately treated with a soda solution to neutralize any acid that may remain in the fibers. Great care should be taken with the process of **neutralizing**, which is accomplished by immersing the wool in a solution of soda of about 4° strength (never more than this) and allowing it to be in the solution for a sufficient time to be saturated thoroughly. Afterwards the wool should be rinsed in pure water.

Wool carbonized with sulphuric acid will gain from 12½ to 15 per cent. in weight after being stored for a sufficient length of time. This is due to the fact that in carbonizing the natural moisture, which is driven from the wool by the intense heat, will be regained if the wool is allowed to stand for some time. No appreciable deterioration of the wool itself takes place if the process of carbonization is properly performed; in fact, it has been found that wool properly treated with acid seems actually to have gained in strength of fiber. One of the chief dangers to guard against is overheating in the dryers, which will yellow the stock and also make it tender.

HYDROCHLORIC-ACID PROCESS

6. Hydrochloric acid is used for carbonizing, mainly in the form of a gas. The process is one that is never applied in America, but is in use to a limited extent in Europe; it is confined mainly to carbonizing rags, as it is a failure on new wool, owing to the tendency it has of turning the fiber yellow. Carbonization by this method is performed by spreading the rags on racks in a chamber heated from 200° to 230° F., where they are treated with the fumes of the hydrochloric (muriatic) acid. The action is exactly the same as that of the sulphuric-acid process and a 2-hour or 3-hour treatment is sufficient, after which the stock should be dusted and neutralized.

Carbonization by the dry, or gas, method is sometimes accomplished in a large, rotating, iron cylinder, which is surrounded by a coil of steam pipes, in order to obtain the necessary heat. The air is removed from the cylinder by a vacuum pump and the fumes of the acid passed in. The rotating cylinder turns the stock over and exposes all parts of it to the action of the gas.

ALUMINUM-CHLORIDE PROCESS

7. The use of aluminum chloride for carbonizing the vegetable matter found in wool is being introduced into some of the best mills and carbonizing plants, superseding the older method of carbonization by the use of sulphuric acid. Aluminum chloride is a milder agent than acid and acts less harmfully on the wool fiber; therefore, there is less danger of injury to the stock. Another advantage of aluminum chloride is that it does not attack the iron that is used more or less in the construction of dryers, hydro-extractors, etc. If wool that has been saturated with sulphuric acid comes in contact with iron before it is dry, the acid attacks the iron and a rust spot is made on the wool. Aluminum chloride also possesses antiseptic properties, to some extent.

8. The wool to be carbonized is saturated, in a box or tank, with a 6° to 8° (Baumé) solution of the chloride from 40 minutes to an hour, and is afterwards partly dried in a hydro-extractor and then completely dried as in the sulphuric-acid process. This completes the carbonization. The wool is then passed through a carbonizing duster and the carbonized vegetable matter crushed and removed. After the wool has been dusted, it is washed with clear water or water with a small quantity of fuller's earth added, as the residue from the chloride is easily removed. *Fuller's earth* is a clay-like substance that is used in the scouring and fulling of woolen cloth.

The action of the aluminum chloride depends on the fact that when a solution of this substance and water is evaporated, the chloride is decomposed and hydrochloric acid is liberated. The acid attacks the vegetable matter and is the real carbonizing agent. Wool carbonized with aluminum chloride will, after being stored for some time, gain about 5 per cent. in weight.

9. The **advantages** claimed for this process, summed up in as few words as possible, are as follows:

1. It is the simplest method and one attended with the least inconvenience to the workmen, there being no disagreeable acid fumes for them to breathe.

2. Wool carbonized with aluminum chloride retains its elasticity, softness, and natural feeling to a greater extent than wool extracted with acid; nor is there the danger of weakening the fiber by overheating that attends the acid treatment.

3. The danger of staining the wool with iron rust is eliminated, as the chloride does not attack iron as does acid. The wool may thus be dried by steam pipes without danger of injury.

10. Among the **disadvantages** of the use of aluminum chloride as a carbonizing agent may be mentioned the following points:

1. The process is apt to be somewhat uncertain, owing to the tendency of the aluminum-chloride solution suddenly to lose carbonizing strength, whereas the sulphuric-acid process is unfailing.

2. Stock carbonized with aluminum chloride will not take certain colors so well as stock carbonized with sulphuric acid.

3. Aluminum chloride has a tendency to decompose into a sticky, greasy compound that coats the inside of the dryers and dusters, and can only be removed by the use of sharp scrapers. This is a disadvantage in dusting, as the duster should at all times be clean, in order to obtain the best results. No compound of this nature results from the use of sulphuric acid as a carbonizing agent.

COMPRESSED-AIR CARBONIZING APPARATUS

11. The aluminum-chloride process of carbonizing is occasionally performed with apparatus designed to be operated by compressed air. With this apparatus, as usually arranged, the carbonizing liquor is not only forced through the wool by compressed air, but the latter also furnishes power for removing the stock from the soaking tanks. The usual arrangement is to have two wrought-iron soaking tanks about 6 feet in depth and 5 feet in diameter. These are connected at the bottom by a suitable pipe provided with a

valve and the tanks equipped with perforated false bottoms. The stock to be carbonized is contained in wrought-iron cages perforated on the bottom and sides and so arranged as to be lowered into the soaking tanks and rest on the false bottom. The carbonizing liquor is stored in a supply tank so placed that the liquor may be run into the soaking tanks by gravity. The compressed air is obtained by means of an air compressor and is stored in a wrought-iron storage tank connected with the soaking tanks by suitable pipes. The compressor automatically maintains a pressure of 60 pounds per square inch in the storage tank.

In operation, the stock to be carbonized is placed in the cage in the first soaking tank and the carbonizing liquor run in from the supply tank until the stock is completely submerged, the connection with the second soaking tank being closed during this operation. The cover is now securely fastened on to the first soaking tank. The second tank is then filled with stock and the connection between the two tanks opened; at the same time the compressed air is admitted to the first soaking tank from the storage reservoir. The pressure thus obtained in the first tank drives the liquor down through the wool in the first tank and up through the stock in the second tank. To resist the tendency of the wool in the second tank to be forced up by the air, a wooden frame is placed across the top.

When the liquor is all out of the first soaking tank, which is indicated by its rising to the same height in the second tank, the connection between the two tanks is shut off, as is also the connection between the first soaking tank and the compressed-air reservoir. Then, by means of an exhaust valve, the compressed air remaining in the first tank is let out and the cover removed. The first tank may now be emptied and refilled, the hoisting and lowering of the cage being accomplished by means of compressed air. The cover is then securely fastened down on the second tank and compressed air from the reservoir admitted to the top of the tank, which forces the liquor (the connection between the two tanks having been opened) down through the wool in

the second tank and up through the wool in the first, which is the reverse of the initial operation.

These operations are repeated until the entire batch to be carbonized has been treated with the chloride solution, after which the liquor is removed from the soaking tanks and stored in the supply tank. This may be accomplished by closing all the outlet valves except the one to the supply tank and admitting compressed air to the soaking tank, whereupon the liquor will be rapidly driven back to the storage tank.

MAGNESIUM-CHLORIDE PROCESS

12. The process of carbonization with magnesium chloride is very similar to that employed with aluminum chloride, the effects also being of a similar nature. The stock to be carbonized is saturated in a solution of magnesium chloride of from 5° to 6° (Baumé) strength for one-half or three-quarters of an hour, and is then taken out and the excess of moisture removed in a hydro-extractor. The stock should next be dried as in the sulphuric-acid process, and after being allowed to cool, dusted and washed as in the aluminum-chloride process.

13. Extracting, or carbonizing, is not confined to raw stock, as very often the cloth is carbonized after it is woven. Woven cloth is carbonized either by sulphuric acid or by aluminum chloride, the object being to remove motes or minute particles of vegetable matter that have not been removed in the process of manufacture and that otherwise would have to be picked out by hand. The action of the carbonizing agents is not confined to motes and such vegetable impurities, but extends to cotton and other vegetable fibers. This fact is made use of in recovering the wool fibers (known as extract) from manufactured goods that contain both cotton and wool. The process that is generally used is the sulphuric-acid one, although the dry-gas method is sometimes employed. The rags that contain both wool and cotton threads are steeped in the acid, dried, crushed,

and dusted after the manner of the raw wool. The cotton is thus removed from the fabric, and the wool that remains is worked over again, i. e., remanufactured.

An interesting method of forming fancy patterns is based on the principle of carbonization. A fabric that contains both woolen and cotton fibers is taken, and a figure or design printed on it with a paste of aluminum chloride, the cloth being afterwards dried at a high temperature. The effect of this is that the cotton is destroyed in those portions of the fabric that were in contact with the chloride, and the cloth in those places becomes so impoverished as to produce a gauze.

MACHINES USED IN CARBONIZING

14. In order to extract the vegetable matter from wool successfully by means of a chemical process, it is necessary to have suitable tanks for soaking the stock in the carbonizing solution. For this purpose wooden tanks of an appropriate size are the most satisfactory, as they are not affected by the solutions and give a maximum of service with a minimum of cost. Round wooden tanks with iron hoops will stand the action of acid better and give longer service than square tanks as usually built with iron rods piercing the wood.

The hydro-extractor used for extracting the excess of moisture from the stock before drying is the same as has been described, with the exception that the basket should be tinned or galvanized in order to render it acid-proof.

In drying wool that has been treated with acid, it will be found impossible to use a dryer that has cotton aprons, as the acid will immediately destroy the aprons. In the case of aluminum-chloride carbonized wool, the stock can be dried with a multiple apron dryer with heated steam pipes between the aprons; but with sulphuric-acid carbonized wool the vapor of the acid will rust the iron pipes, and the wet rust dropping on the wool or the wool coming in contact with the pipes will result in stains. All metal in the dryer that comes in contact with stock that is saturated with acid must be tinned or galvanized. The aprons in some dryers are made of galvanized

wire cloth, which makes a good apron for acid-treated wool. A two-section carbonizing dryer is best and gives the most satisfactory results for this work, the machine being arranged to dry the stock in the first compartment and carbonize it in the second.

THE CARBONIZING DUSTER

15. After the wool comes from the dryer, the vegetable matter that was in the stock before carbonization is greatly changed in character. Instead of being tough and clinging to the fibers of wool with great tenacity, the burrs are brittle and may be easily crushed and shaken out of the stock. The object, therefore, of the carbonizing duster is to crush the burrs and other vegetable matter rendered brittle by the agent used in extracting and to remove them from the wool fibers. A duster built especially for handling carbonized stock is shown in Fig. 1. The principle on which this machine operates is similar to that of the cone duster previously described, with the exception that the carbonizing duster is provided with three pairs of heavy crush rolls *b* for the purpose of reducing the carbonized burrs to powder before the stock is subjected to the action of the rotating cylinder. The rolls are connected by gears and have springs and hand wheels *c* for controlling the pressure, which should be regulated so as to be heavy enough to crush the carbonized burrs, but not enough to cut the wool. The arrangement of the six rolls in this machine, and in fact in nearly all carbonizing dusters, is such that only three crushing points are obtained, as the rolls are arranged in pairs. A better arrangement is to have three bottom rolls and two top rolls, the latter resting between the bottom rolls, so that four crushing points are obtained, although there is one less roll on which the pressure has to be regulated. If this arrangement is used, however, the springs for applying the pressure should be somewhat stronger, as the pressure is divided over two points instead of being concentrated at one. In most carbonizing dusters, the width of the crush rolls is too narrow. A better method is to have wider crush rolls, so that the

stock can be fed thin and a better crushing obtained whereby none of the burrs will pass to the duster without being crushed. After passing the crush rolls, the stock can be

Fig. 1

directed to a narrow apron feeding the duster. Sets of crush rolls can be obtained entirely separate from a duster.

The machine illustrated is built with a worker *e*, which greatly assists in opening out the stock. In operation, the

worker rotates slowly backwards, its teeth engaging with the wool that is carried around by the main cylinder *f*. The worker is protected by a sheet-iron bonnet, which is shown raised from the worker. The fan *d* is on the top of the machine; and, since the space under the screen, which is beneath the main cylinder, is air-tight, the air drawn by the fans enters at each end of the main cylinder around the main bearings of the same, through apertures provided for that purpose. Beneath the fan there is a screen that retains the stock, being so made that it may be drawn out for cleaning. The air that passes through the upper portion of the machine sucks away light dust, etc. from the wool, while the heavy particles of dirt fall by gravity through the screen *g* under the cylinder. The screen is made in two sections, one of which may be withdrawn from the front of the machine, as shown in Fig. 1, and the other from the rear. The draw that removes the screen is also provided with a door for access in cleaning out the refuse without removing the draw itself. A good position for the fan of a duster is below the screen, or grate, since if placed in this position, the current of air produced not only removes the dust from the stock, but also aids the fall of the heavier particles. When the fan is on the top of the machine, the current of air, being upwards, tends to hinder the fall of matter through the grate. The cylinder *f* is provided with heavy iron teeth for beating the wool. The machine, being provided with tight and loose driving pulleys, does not require a countershaft for driving. The duster illustrated in Fig. 1 occupies floor space 9 feet by 7 feet and requires a 3½-inch or 4-inch belt to drive it, about 4 horsepower being necessary.

16. Operation of Duster.—In operation, the stock is fed either by hand or by means of a self-feed on the feed-apron *a*, which carries the wool to the iron crush rolls, which successively operate on the stock and reduce to powder the previously carbonized vegetable matter that is contained in the wool. The wool is now delivered to the action of the main cylinder, which revolves upwards at a speed of about

400 revolutions per minute, although sometimes a speed of 450 revolutions is used when stock with a short fiber is to be treated. A longer fiber will require the slower speed, in order to prevent damage to the stock by breaking the fibers. The action of this cylinder, combined with that of the worker *e*, which operates in conjunction with it, is to shake, or beat, out all the dust and pulverized vegetable matter from the wool, the heavier particles of which fall through the screen *g* into a compartment under the cylinder whence the refuse can be periodically removed. The lighter foreign matter and dust are removed by the current of air generated by the fan through the upper part of the machine and conveyed outside of the mill through a suitable pipe. The wool travels from the small end of the cone-shaped cylinder toward the large end, and is finally thrown out through a square orifice at the end of the cylinder in the rear of the duster.

SARGENT'S LOW FEED

17. In connection with the Sargent multiplex burr picker, illustrated in *Burr Picking*, a self-feed attachment is shown. This self-feed is one that is in common use and is adapted not only to burr pickers but to mixing pickers and to carbonizing and other dusters, to which it is often applied. The object of this machine is to feed the stock evenly and uniformly to the duster or picker, and supplant the more laborious method of hand feeding. The principle on which the machine operates is that of a traveling lifting apron filled with spikes that lift the stock from the hopper and deposit it on the feed-apron of the machine to be fed. The apron is made of hardwood slats attached to endless belts, and is supplied with sharp spikes from 1 inch to $1\frac{1}{2}$ inches in length that engage with the stock in the feed-box; the wool is thus carried to a revolving comb that combs off all excess of wool and evens the feed.

The comb in this machine is a cylindrical revolving one, and is fitted with two rows of teeth, which are withdrawn from the surface of the comb after coming in contact with

the stock on the spiked apron; this is accomplished by means of an eccentric, which works in a wide-slotted arm to which the teeth of the comb are attached through suitable connections; by this means the stock is prevented from winding around the comb. There is a traveling apron in the bottom of the hopper for the purpose of keeping the stock constantly pressed against the lifting apron. A *beater*, or *stripper*, is provided for stripping the stock from the lifting apron and depositing it on the feed-apron of the duster or other machine to be fed. The speed of the beater should be about 235 revolutions per minute, and the machine is driven from this shaft. The speed of the lifting apron may be changed by means of cone pulleys and change gears. The floor space occupied by the machine, when attached to another machine, is 4 feet 6 inches in length.

18. Operation.—In operation, the wool or other stock is placed in a large, commodious hopper, or feed-box, from which it is extracted by the lifting apron. The wool is kept in constant contact with the lifting apron by means of the traveling apron in the bottom of the hopper. As the stock is elevated to the revolving comb, large bunches of wool are knocked back into the hopper, and the amount of stock fed is thus made uniform and the apron evenly loaded. The stock is then stripped from the lifting apron by the beater, and falls on the feed-apron of the duster or burr picker. The feed requires about 1 horsepower for driving purposes.

WOOL MIXING

INTRODUCTION

1. Importance of Proper Mixing.—Although the importance of proper methods of *mixing* stock before subjecting it to the carding process is often underrated, it may be stated with truth that the character of the yarn ultimately produced depends, to a great extent, on the manipulation of the stock at this point. **Mixing** is the blending, or amalgamation, of different colors or qualities of wool, or of wool and cotton, wool and shoddy, or similar materials, and is resorted to for various purposes. Sometimes the mixture is simply one of colors; for instance, it may be desired to produce a gray mix; this result will be obtained by blending wool that has been dyed black with pure white stock in proportion to the shade of gray desired in the mixed yarn. Again it may be found that a certain grade of goods is costing too much. In such a case, if the cost of production is already reduced to a minimum, the only recourse is to reduce the cost of the material entering into the goods. If a high grade of goods is being made, the cost of the material may be reduced by blending a cheaper grade of wool with the finer stock previously used. If a medium grade of goods is being manufactured, a little shoddy or cotton may be mixed with the stock; while if the lowest grades of goods possible are being made, various kinds of fibers may be blended together, material possessing any spinning qualities at all being of value.

2. At first thought it would seem a comparatively simple matter to mix two or more materials together and spin a yarn from the blended stock, but when it is considered that the materials to be mixed are often radically different in physical

structure and that they should be so blended as to be indistinguishable one from the other, the difficulty will be recognized. The yarn spun from the mixed stock should also be as even and level as though only one material were used and, if the mixture is one of color, the blend should be so perfect that the colors of the original ingredients cannot be distinguished except on close inspection.

It matters little how perfect are the color and the design of a fabric, or how carefully the other processes of manufacture are accomplished, if the mixing of the raw stock has been carelessly or imperfectly performed, the finished cloth will show more or less imperfections. Sometimes the cloth will be covered with specks, usually of the lighter-colored stock used in the mix; such cloth must either be sold for seconds or piece-dyed. A thread composed of poorly mixed materials when examined under a microscope reveals, instead of the perfect amalgamation of the individual fibers of different materials, a mass of the fibers of one material in one part and a mass of the other in another part of the thread. The evenness of the thread itself is liable to imperfections, since it is impossible to spin an even thread from unevenly mixed stock. Especially is this true in a case where the mix is composed of materials of different spinning properties and of different lengths of staple. In cases like this the roving will not draw well in spinning and the yarn will be liable to contain *twits*. If the spinner cannot make a first-class yarn out of poorly mixed materials, neither can the weaver make a perfect piece of cloth from an inferior yarn, nor the dyer and finisher produce superior results.

3. Mixing is resorted to, not only for combining colors or qualities of stock, but is also occasionally used in the best mills in lots of one color and quality, since any mistakes in sorting, scouring, dyeing, etc. are by this process equally distributed through the entire batch. The more that wool is mixed and worked over, without injury to its natural qualities, length of staple, and physical structure, the evener will be the yarn and cloth made from it.

METHOD OF LAYING OUT MIXES

4. Whatever may be the materials to be mixed, the same general method is followed in mixing; for though the process of mixing has been in use for many years no improvement has been found on the old method, which consists of spreading the materials to be mixed in thin alternate layers on the floor of the picker room. For a simple example, suppose that a gray mix composed of 50 per cent. black and 50 per cent. white wool is required; the method of procedure will be as follows: Equal quantities of black and white wool will be weighed out first and then, on a clean floor space in the picker room, a layer of black wool will be spread about 10 or 12 feet square, depending on the number of pounds of stock to be mixed, and 7 or 8 inches in depth, care being taken to have it spread evenly and of uniform depth. Then a similar layer of white wool will be spread over the first layer of black, care being taken to have approximately the same quantity of stock in the layer of white as in the layer of black wool. Then another layer of black, then white, and so on until the lot is completed.

Fig. 1

The mix is now ready to be put through a mixing picker. In taking the stock from the pile on the floor, great care should be taken to break it down from the side or end and not from the top; otherwise, the benefit of laying out the stock in successive layers is lost. If the stock, however, is taken carefully from the end, a portion of each layer will go into the self-feed of the mixing picker in every armful. It is customary to oil the stock as each layer is spread during the mixing, but this process will be described later. In many

instances, a mix contains more than two materials; in some cases three, four, or even more components enter into the mixture.

Fig. 1 represents the mixing of three colors of the same material, or three materials. In the illustration, the dark-shaded divisions represent material or color No. 1; the medium-shaded divisions, material or color No. 2; and the light-shaded divisions, material or color No. 3.

5. In making fancy mixes, sometimes with a little study advantageous methods of laying out the mix may be devised; for instance, suppose that a fancy mix composed of 50 per cent. black wool, 25 per cent. white, and 25 per cent. olive is required. If the layers were laid out on the floor in the order and percentages given, to make the individual piles of different-colored wools come out even, or be used up at the same time, it would be necessary to make the layers of black wool twice as thick as those of either the white or olive wool. This would not distribute the different ingredients so well as when the layers of stock were made of the same thickness and distributed in the following order: black, white, black, olive; this process would be repeated until the wool were all used up, and if the layers were of the same thickness they would come out even. This method, of course, would be impossible if there were only two ingredients in the mix.

6. In laying out a mix containing different percentages of materials, where it is not possible to divide the stock so that each layer shall be of the same thickness, care should be taken to make the layers of each material vary in thickness as near as possible according to the percentage of that material in the total blend; otherwise, the ingredient of which there is the smallest amount will soon be exhausted and the rest will have to go on top, thus destroying the evenness of distribution and the uniformity of the blend.

In dealing with mixes of great diversity of quantity as well as color and quality of components, it is often customary to prepare a temporary mix with the small quantity and a part of the larger quantity of material and then finally blend

this temporary mix with the rest of the stock. In this manner the small quantity of one ingredient is more evenly distributed through the large amount of the other. For instance, suppose that a mix composed of 90 per cent. black and 10 per cent. white is required. If these are mixed directly there is such a small amount of white present that it will be difficult to distribute it evenly, so that if the amount of mix required is 500 pounds, a temporary mix of 50 pounds of white and 100 pounds of black making a mix of 150 pounds will be prepared. The temporary 150-pound mix will then be mixed with 350 pounds of black, making 500 pounds of the final mix, which will contain only 50 pounds, or 10 per cent., of white wool.

7. In mixes where several colors are used, it is sometimes the custom to mix the smaller proportioned colors together first and run them through the mixing picker, and afterwards mix this temporary mix with the color that occurs in the greatest proportion. For instance, if a mix were being made of 40 per cent. black, 20 per cent. brown, 20 per cent. olive, and 20 per cent. slate, the custom would be to first mix the brown, olive, and slate and afterwards blend this temporary mix with the black. This would insure the colors being more evenly distributed.

In making a mix where there is an extremely small amount of one ingredient, such as an Oxford mix containing 97 per cent. of black and 3 per cent. of white, it is customary to card that stock which enters into the blend only in a small percentage before it is mixed, in order to make it more lofty and enable it to be more uniformly distributed. This is usually accomplished by having an extra breaker card and allowing the stock to drop on the floor from the doffer comb. Or, if this is not convenient, it may be run through the mixing picker several times before mixing. These machines will be fully explained further on.

8. Care must be taken in making fine mixes to have all the materials of approximately the same length of fiber if the best results are to be obtained. If short fibers are

mixed with long ones, that is, extremely long in comparison, they do not strengthen the yarn to a great extent, although they make the yarn more bulky. There is also a tendency for the short fibers to bunch up during the carding and the drafting of the roving in spinning and produce twits in the yarn.

In regard to the number of times that a mix is passed through the mixing picker, little can be said, as it all depends on the condition in which the stock is received from the preceding processes and the materials and colors that are being blended. If the stock is well opened and lofty and the mix is carefully made, it will probably not be run through more than twice. Some materials are more difficult to blend thoroughly than others and some colors also have a tendency to show up more than others if not thoroughly amalgamated, even if the stock is the same. The only way to tell whether the stock needs to be passed through the mixing picker again is to examine the mix and see if the fibers are well and evenly blended; if not, and they occur in separate patches, it is well to run the mix through the picker again. Some mills make a practice of running mixes through the picker three times, while others consider twice sufficient. Definite rules, however, should never be allowed to regulate the handling of all mixes.

9. Mixing Wool and Shoddy.—In view of the competition that is now prevalent, many manufacturers deem it wise to mix varying percentages of cheaper material into their goods in order to gain the market against a competitor by underselling him. One of the materials mixed with the wool to cheapen the cost of the raw stock is **shoddy.** This material is, literally, the worked up waste of old, soft, woolen fabrics, such as stockings, knitted fabrics, flannels, and other woolen goods that have not been milled or felted; but in the mill the card waste, strippings, etc. are sometimes considered as shoddy and after being dusted are worked up with the new wool. Usually, however, soft waste is worked up as far as possible with the batch in which it was

made, but hard waste is run through a Garnett machine or rag picker and made into shoddy.

In order to make a good mix with shoddy, a short, fine wool will be found to give the best results in the majority of cases. The reason for this is that the shoddy fibers are always of extremely short length and it is difficult to mix a long fiber with a short one and get good results. In selecting shoddy to mix with wool, the length of the shoddy fiber is one of the main points to be observed; the longer the fiber, the more valuable is the shoddy. Where a mill is buying shoddy, care should be taken that it is not adulterated as, the fiber being naturally short, it is easy to adulterate it with extremely short and inferior material that can hardly be detected. Shoddy is not often worked alone, as the resulting yarn would be tender and almost impossible to spin, but in mixtures with pure wool the shoddy has its purpose in *feeding* the yarn, or making it more bulky.

10. The percentage of shoddy used depends on the class of goods that a mill is running on. If a good grade of goods is being made, it is not wise to cheapen the stock too much and, even if shoddy is used, care should be taken to use a good grade; on the other hand, if the goods are cheap, often the larger part of the fabric is shoddy with only enough new wool fibers to hold the yarn together. In blending wool and shoddy, it is a good practice first to run the materials through the picker separately and then to make a mix on the floor by spreading the materials over each other in successive layers. The thinner the layers of the different materials and the more of such layers, the better is the mix.

In running a blend through the mixing picker, it must alway be remembered that the success of the mixing depends largely on the manner in which the stock is taken from the pile spread out on the floor. The stock must always be removed from this pile by taking an armful vertically down from the side or end, and not from the top; this insures the complete amalgamation of the several layers. While a little shoddy may be used advantageously in connection with

wool, care must be taken not to make the percentage of the cheapening element in the mix large enough to make the spinning of the yarn so difficult as to involve much extra expense; otherwise, the adulterated yarn will be found to cost almost as much as a pure woolen yarn, owing to the extra cost of manufacture due to lessened production and excessive waste.

11. **Mungo,** which is the worked-up waste of hard woolen goods such as overcoatings, beavers, meltons, and other hard-felted and milled goods, is mixed with new wool, as is also **extract,** or the recovered wool fibers of union goods composed of wool and cotton or other vegetable fibers. **Flocks,** or the short, fluffy woolen fibers occurring as the waste from nappers and shearing machines, are also used in connection with raw stock for producing mixtures, although they are more often added to the cloth during the finishing.

12. **Mixing Wool and Noils.**—These two materials are often blended. **Noils** are the short fibers removed from medium- or long-stapled wools by the combing process in the production of worsted yarns; they are pure wool and are sometimes used alone for the production of low-grade fabrics, but they do not possess the elasticity nor the natural wavy and lustrous nature of the original wool, although they make one of the best materials for mixing with wool. Noils should be carbonized before mixing, as they are removed by the comb in connection with burrs, chaff, straws, seeds, and other vegetable matter, the action of the comb being to remove all the impurities in a worsted card sliver as well as the short fibers. Noils and pure raw stock are mixed in the usual manner by being spread in alternate layers and then passed through the mixing picker.

13. **Mixing Wool and Cotton.**—The addition of cotton to wool in the manufacture of union fabrics is a common practice. Although the adulteration of woolen goods with cotton is not looked on with favor by many people, indeed is greatly deplored, there can be no doubt but that it is beneficial when used in suitable proportion in connection with

low classes of goods manufactured from inferior wool, since the cotton imparts to the fabric strength and wearing qualities that would otherwise be lacking. When cotton is introduced into a fabric it may either be in the form of separate threads of pure cotton or the materials may be mixed in the raw stock.

When cotton is mixed with wool it should first be run through the burr picker in order that it may be opened out and made fluffy, so that it will amalgamate well with the wool fiber and not form into individual bunches. It must be remembered that shoddy, mungo, extract, flocks, and noils are in reality pure wool, although more or less injured by the operations to which they have been subjected; but cotton is different in structure and requires different manipulation.

As has been said, the cotton must be picked and rendered open and lofty before being mixed with the wool, and it is all the better for being passed through a single carding process if a fine mix is to be made. The wool must be oiled and also picked before the mix is made; in no case should any oil be applied to the cotton. After the wool is well oiled and picked, the mix can be made. The stock should be laid out in successive layers of cotton and wool and afterwards run through the mixing picker a sufficient number of times to insure perfect amalgamation.

The process of making the so-called *vigogne yarn* is as follows: This yarn is sometimes composed of cotton and wool in about equal proportions, although often only from 3 to 10 per cent. of wool is used. The wool should be of quite fine fiber in order to blend well with the cotton and should also be well scoured, dried, burr-picked, and oiled. The cotton should be of good length of staple and should be run through the burr picker and a single carding process, which is performed on a woolen card. The wool may also be subjected to a single carding process if it is desired to make the best mix possible. The stock is then mixed, in the usual manner, by making a pile of the materials in alternate layers, taking it down vertically from the end, and subjecting it to two or three picking operations. It is, of course, only for fine work that so much trouble is taken as to card the stock. The ordinary method,

which gives excellent results, is to oil the wool and pick it, run the cotton through a burr picker, and then blend the wool and cotton in the right proportions and run the mixture through the mixing picker several times.

Cotton is used in connection with wool for low classes of worsteds, cassimeres, tweeds, flannels, etc. The cotton fiber should be as long as possible and the wool as fine as the grade of goods will allow, with a medium length of staple, and should also be sound, strong, and full of life and elasticity. As it is desired to have the goods resemble wool as nearly as possible, care should be taken to regulate the percentage of cotton according to the class of goods to be made, always using as little as possible to get goods out at the proper cost. On dress goods, flannels, and boys' suitings, from 50 to 75 per cent. cotton can be used. The cheapest possible lots of cotton are often selected, but it is better to have some consideration for the character of the wool. Where the wool is not very fine, a coarse, wiry cotton, as rough Peruvian or Brazilian, may be used with good results if the goods are dyed dark shades. American cotton, however, is generally used in American mills and is well suited for blending with wool. For mixing with fine wool, sea-island cotton, which has a long staple, is often used.

14. If a large percentage of white cotton is to be used and the yarn or cloth sold is white, the cotton should have a blue stain put on it in order to kill the chalky white appearance, which is never seen in pure woolen goods. In making a cotton-and-wool mix composed of 50 per cent. white and 50 per cent. black, one material should not be of one color, but preferably half of the wool should be dyed black and the other half left white; the same should be done with cotton and the results will be better than if the mix were made with black wool and white cotton, or vice versa. When using black cotton in wool mixes, the cotton should be dyed a blue black in order to overcome the rusty look of ordinary black cotton, which makes the goods look cheap.

In fancy mixes have the dyed cotton as fast as possible, especially if there is any white or light-colored ingredient in the mix. The reason for this is that unless the cotton dye is perfectly fast, it will *bleed*, or run, in finishing, staining the light-colored material in the mix. The cotton should for the same reason be fast-dyed in goods that have white or light-colored yarns in the pattern. In particular mixes, the stock is laid out in layers the second time, after being run once through the picker. In mixing only small proportions of cotton with wool it is not necessary to observe so many details; still the wool should be oiled separately, care being taken not to let the mix stand too long and thus allow the cotton to absorb the oil from the wool, and the materials should always be first picked separately.

If the mix is well made, the resulting fabric will be free from specks and the care put into the mixing will be well repaid. The cards must be in good condition for working cotton-and-wool mixtures, and the wool used must have good fulling properties, owing to the total absence of this characteristic in the cotton. If a large percentage of cotton is used, the cloth will have to be set finer in the loom in order to obtain the desired finished texture; as the more cotton used, the less the cloth will be shrunk in finishing. When cotton and wool are mixed and spun together, the cotton, if of long staple, has a tendency to go to the core of the thread and be entirely covered by the wool, which stays on the outside of the yarn.

15. Mixing Wool and Silk.—It is sometimes desirable to mix wool and silk waste in the production of fancy mixes. This is attended with some little difficulty, as the silk is extremely hard to card owing to its fluffy nature and its liability to become charged with static electricity if dry and subjected to friction.

When silk is blended with wool, it is desirable to have the silk the color of the largest ingredient in the mixture; if, for instance, the mixture is composed of 80 per cent. black and 20 per cent. white, the silk waste should be dyed black in

order to make the blend look even. The silk waste should first be carded before any attempt is made to introduce it into a mix.

It is important that both ingredients should be free from grease and gum. In oiling wool-and-silk mixes, the oil used should be of good quality and free from any acid, the wool being oiled separately as with cotton-and-wool blends. No oil should be applied to the silk. If there is quite a large percentage of silk in the mix and trouble from electricity or from an excessive amount of flyings is experienced in the carding, it may be necessary to dampen the silk with water before mixing. This can be done by spreading the silk in quite thin layers on the floor and covering it with wet bagging. If the bagging is wet enough and allowed to remain on the silk over night the stock will become sufficiently damp. If water is applied directly to the silk, the fibers are liable to mat.

SUMMARY

16. In general, when making a mix, the material should be spread quite thinly over a large area. As many layers as convenient should be made, and if one material enters into the combination only in a very small proportion, care should be taken to make first a temporary mix with this ingredient and a part of the one that forms the ground, or bulk, of the mix. Always break down the pile vertically from the end and run the stock through the mixing picker a sufficient number of times to insure a perfect blend.

If making a cotton-and-wool or wool-and-silk mix, oil the wool separately; otherwise, the cotton and silk will be difficult to mix and card. It is not wise to depend on the materials becoming mixed in the cards. They should be mixed first, so as not to make a mixing picker of the first breaker card. As great care should be taken with all-wool mixes as with wool and cotton in order to insure evenness and perfection throughout the operations following.

FINDING THE COST OF MIXES

17. In mixing materials that vary in cost, it is often necessary to ascertain the cost of the blend per pound in order that the value of the resultant yarn or fabric may be estimated. Again, it may be necessary to obtain the percentage of a cheaper material required in a blend in order that the mix may be produced at a given value. Many other conditions also arise in connection with blending raw stock that require accurate figuring in order that the cost of the finished goods or their character may not be altered.

18. To find the cost per pound of a mix composed of two or more materials of different costs either in equal or unequal proportions:

Rule.—*Multiply the number of pounds of each material by its cost per pound, and divide the sum of the products thus obtained by the total number of pounds in the mix.*

EXAMPLE.—What is the cost per pound of a mix composed of 45 pounds of wool at 28 cents per pound, 25 pounds of shoddy at 14 cents per pound, and 10 pounds of cotton at 9 cents per pound?

SOLUTION.— 45 lb. of wool at 28 ct. per lb. will cost \$12.60; 25 lb. of shoddy at 14 ct. per lb. will cost \$3.50; 10 lb. of cotton at 9 ct. per lb. will cost \$.90. The total cost of the mix will be $\$12.60 + \$3.50 + \$.90 = \$17$. Since the total weight of the mix is 45 lb. + 25 lb. + 10 lb. or 80 lb., the cost per pound of the mix will be $\$17 \div 80 = \$.2125$, or $21\frac{1}{4}$ ct. Ans.

19. To find the proportion of each ingredient in a mix composed of materials of different costs, in order that the resulting blend may have a definite cost per pound:

Rule.—*Arrange the respective values of each material in a column and place the desired cost of the mix at the left. Link these values together in pairs so that one element of each pair is greater and one less in value than the average cost. Find the difference between the average price and each element of a link*

and write it opposite the other element of the same link. Each of these differences has the same relation to their sum as the quantity of each material has to the mix.

EXAMPLE 1.—It is desired to mix enough cotton costing 10 cents per pound with wool costing 22 cents per pound so that the resultant mix will have a value of 18 cents per pound; what is the proportion of each ingredient necessary?

SOLUTION.—The difference between 18 and 22 is 4, which is placed opposite the 10, to which the 22 is linked, while the difference between 18 and 10 is 8, which is placed opposite the 22, to which the 10 is linked. From this it will be seen that each 12 lb. of mix should contain 4 lb. of cotton and 8 lb. of wool. Ans.

$$18\left\{\begin{array}{ll} 10 & 4 \\ 22 & 8 \end{array}\right.$$

PROOF.—This example can be proved, by applying the rule in Art. **18**, as follows: 8 pounds of wool at 22 cents per pound will cost \$1.76; 4 pounds of cotton at 10 cents per pound will cost \$.40. The total cost of the mix will be \$1.76 + \$.40 = \$2.16. The cost per pound of the mix will be \$2.16 ÷ 12 = \$.18, or 18 cents.

The rule in Art. **19** can be applied in case more than two ingredients enter into the mix, but care must always be taken to link together a higher and a lower value than the desired average.

EXAMPLE 2.—Suppose that four materials, A at 6 cents per pound, B at 10 cents per pound, C at 16 cents per pound, and D at 20 cents per pound are to be blended; what proportion of each will be necessary so that the resulting mix will have a value of 14 cents per pound?

SOLUTION 1.—The difference between 20 and 14 is 6, which is placed opposite 10, to which 20 is linked; the difference between 16 and 14 is 2, which is placed opposite 6, to which 16 is linked; the difference between 10 and 14 is 4, which is placed opposite 20, to which 10 is linked; the difference between 6 and 14 is 8, which is placed opposite 16, to which 6 is linked. From this it will be seen that each 20 lb. of the mix should contain 2 lb. of A, 6 lb. of B, 8 lb. of C, and 4 lb. of D. Ans.

$$14\left\{\begin{array}{ll} 6 & 2 \\ 10 & 6 \\ 16 & 8 \\ 20 & 4 \end{array}\right.$$

PROOF.—This example can be proved, by applying the rule in Art. **18**, as follows: 2 pounds of A at 6 cents per pound will cost 12 cents; 6 pounds of B at 10 cents per pound

will cost 60 cents; 8 pounds of C at 16 cents per pound will cost 128 cents; and 4 pounds of D at 20 cents per pound will cost 80 cents. The total cost of the mix will be 12 + 60 + 128 + 80 = 280 cents. The cost per pound of the mix will be 280 ÷ 20 = 14 cents.

In a case like this it should be noted that by linking different quantities together, taking care to link a higher and a lower value than the required average, the proportions of the different ingredients may be varied and at the same time the correct average cost obtained. To illustrate, take the same example again.

Solution 2.—The difference between 20 and 14 is 6, which is placed opposite 6, to which 20 is linked; the difference between 16 and 14 is 2, which is placed opposite 10, to which 16 is linked; the difference between 10 and 14 is 4, which is placed after 16, to which 10 is linked; the difference between 6 and 14 is 8, which is placed after 20, to which 6 is linked. From this it will be seen that each 20 lb. of the mix should contain 6 lb. of A, 2 lb. of B, 4 lb. of C, and 8 lb. of D. Ans.

$$14\left\{\begin{array}{l|r} 6 & 6 \\ 10 & 2 \\ 16 & 4 \\ 20 & 8 \end{array}\right.$$

Proof.—This example can be proved by applying the rule in Art. **18.** 6 pounds of A at 6 cents per pound will cost 36 cents; 2 pounds of B at 10 cents per pound will cost 20 cents; 4 pounds of C at 16 cents per pound will cost 64 cents; 8 pounds of D at 20 cents per pound will cost 160 cents. The total cost of the mix will be 36 + 20 + 64 + 160 = 280 cents. The cost per pound of the mix will be 280 ÷ 20 = 14 cents.

In the examples given two of the materials cost more and two less than the required cost of the blend; sometimes, however, only one of the materials may be more or less than the average cost. In a case like this all the other values are linked to this one and the differences added together.

Example 3.—Four materials, A at 8 cents per pound, B at 10 cents per pound, C at 15 cents per pound, and D at 22 cents per pound are to be mixed; in what proportion must each enter into the blend in order that the average cost shall be 17 cents?

SOLUTION.—The sum of the differences between the values of A, B, and C and 17 gives the proportion of D that enters into the mix, or 18 lb. in every 33 lb. of the mix, while the difference between 22 and 17, or 5, gives the proportion of each of the other materials.

$$17\left\{\begin{array}{l} 8 \\ 10 \\ 15 \\ 22 \end{array}\right. \qquad \begin{array}{r} 5 \\ 5 \\ 5 \\ 9+7+2=18 \end{array}$$

After having found, by the preceding rules, the amounts in which each material enters into the blend, it is a comparatively simple matter to find by proportion the amount of each required in any given number of pounds of a mix.

MIXING PICKERS

20. After the materials composing a mix have been carefully spread in layers on the floor of the picker room, the next operation is to pass the stock through a machine designed to blend and intermingle the various components in such a manner that a homogeneous mix is obtained. In America, the machine most commonly used for this purpose is the **mixing picker**; while in Europe, and to a small extent in America, the same results are obtained with a *Fearnaught*, a machine totally different in principle from the mixing picker. Another object of the mixing picker is to open out the wool so that it will be in suitable condition for feeding to the cards.

The principle on which the mixing picker operates is that of opening the wool and intermingling the fibers by means of a rapidly rotating cylinder armed with strong teeth curved forwards in the direction in which the cylinder rotates.

DAVIS & FURBER MIXING PICKER

21. Construction.—The main, or picking, cylinder of this machine, as shown in Fig. 2, consists of six wrought-iron lags l_1 mounted on three or four spiders l, according to the width of the machine. The lags are firmly bolted to the inside spiders and, being fitted into slots in the two outside

ones, are firmly secured by means of heavy wrought-iron hoops that are shrunk over their ends. The teeth l_1 for

FIG. 2

opening the stock are of cast steel firmly screwed into the lags of the cylinder and fastened by means of setscrews, so

as to preserve the alinement of the points of the teeth by preventing them from turning, as they would be liable to do in course of time if simply screwed in. Teeth fastened in this manner can readily be removed if broken and new teeth substituted. The shape of the teeth is such that they will engage with and open the stock without injuring or breaking the staple.

The picking cylinder works in connection with the grate *g*, Figs. 2 and 6, in a manner similar to that employed in burr pickers and dusters, and a considerable amount of dirt and other foreign matter that has escaped the previous operations is allowed to drop through this grate into the space underneath that is provided for its reception. The grate in this machine is constructed of iron bars in such a manner as to expose the least amount of surface possible for the accumulation of grease or gummy deposits, which, of course, are undesirable, as they tend to clog the grate. The grate is hinged at one end and may be lowered or raised by means of the crank *r*, Fig. 2, conveniently located at one side of the machine. This crank operates a pinion gear g_1, Fig. 6, which by means of a rack g_2 imparts movement to the grate. This arrangement greatly facilitates the operation of cleaning the grate. When raised, the grate is locked in place by means of two pins *s*, Fig. 2, on which it rests, one on each side of the machine. The grate is shown lowered from the picking cylinder in Fig. 2. The refuse is removed from underneath the machine at either side, for which purpose removable panels *p* are provided, the one shown in Fig. 2 being removed from the machine.

The feeding arrangement on this machine differs from those on other machines. The stock is not fed by a pair of feed-rolls but by a single roll *j* working in conjunction with a concave dish, or shell, *k*, the arrangement being sometimes known as the shell-and-pin feed. (See Fig. 6.) The curve of the dish is the same as that of the circumference of the feed-roll. The stock is taken by the feed-roll and, being held against it by the dish, is delivered to the cylinder, which revolves close to the edge of the dish. While this

method of feeding is sometimes advocated for the reason that the stock is better opened in being taken by the cylinder from the edge of the dish, it is not so good as a pair of cockspur feed-rolls, because the single roll is liable to choke up while in operation. In order to remedy this, however, the pins are set into the roll at a slight angle, so that the action of the picker cylinder will tend to strip the feed-roll. This machine is made with a pair of cockspur feed-rolls if so desired.

Allowance is made for a vertical motion of the feed-roll, which is controlled by two levers *m*, Fig. 2, one on each side of the machine. These levers have heavy weights *n* suspended from their extremities and are so arranged as to bear on the journals of the feed-roll. This allows any bunches in the stock or inequalities of feeding to raise the feed-roll and prevent the machine from being strained or broken. The feed-apron *h* is of the usual type, composed of wooden slats fixed on endless traveling belts, a means being provided for taking up the slack as the apron stretches from wear. Sometimes, however, the slats of the feed-apron are made of iron, the object being to make the machine fireproof as far as possible, since a machine of this description will become very greasy and there is danger of the swiftly rotating cylinder striking fire and starting a conflagration.

22. Operation.—In operation, the wool or other stock is fed either by hand or by a self-feed, as shown in Fig. 6, on a traveling feed-apron *h*, which delivers it to the straight-toothed feed-roll *j*. The stock is held against this roll by the stationary concave dish and the roll in rotating carries the wool to the main cylinder, which is armed with strong curved teeth about 2½ or 3 inches long, which comb out the wool as it is held on the edge of the dish by the feed-roll. The cylinder revolves down past the feed-roll and makes from 700 to 1,000 revolutions per minute, according to the width of the machine.

As the wool is taken from the feed-roll by the cylinder it is swept down over the grate *g* and a great deal of the

foreign matter remaining in the stock beaten out and allowed to fall through the grate, while the picked stock is carried by the current of air generated by the rapidly rotating cylinder through the outlet m_1 to the gauze room.

23. The machine described is made in sizes from 24 inches to 48 inches wide and requires from 3 to 8 horsepower for driving. The larger sizes, which require more power, are made with a pulley on each side allowing two belts to be used for driving. This, of course, requires a countershaft. The diameters of the pulleys are from 10 inches to 14 inches, according to the width of the machine. The capacity of the largest machine is from 2,000 to 2,400 pounds per hour, the narrower machines producing less in proportion to their width.

ATLAS MIXING PICKER

24. Construction.—The mixing picker shown in Fig. 3, although similar in general principle, is somewhat different in a few points from the machine just described. The object is the same as that of all other mixing pickers; namely, to open the stock for the cards and also to mix thoroughly and blend any mixtures of colors, qualities, or materials that may be passed through. The only wood used in the construction of the picker is for the feed-apron slats, and the machine is therefore practically fireproof and especially adapted for the use of oiled stock.

The feed-rolls of this machine are one of its distinctive features and instead of a single roll or a single pair of rolls there are two pairs j_1, j_2, the second pair running one-third faster than the other pair; this makes what is known as a *draft* between the two sets of rolls. In textile machinery when fibers are drawn between two or more pairs of rotating rolls and one pair of the rolls rotates faster than the other, a draft is said to be produced. The amount of draft where the two pairs of rolls have the same diameter is found by dividing the speed of the quicker rolls by the speed of the slower

ones. Thus, if one pair of rolls makes 14 revolutions per minute, and another pair 21 revolutions per minute, both being the same diameter, the draft is $\frac{21}{14} = 1.5$.

25. Driving.—The driving of the feed-rolls is as follows: A pulley on the picker-cylinder shaft on the left side of the machine drives a pulley on the first auxiliary shaft, which is located at the rear of the machine. This drive is not shown in Fig. 3, being on the opposite side of the machine. A pulley on this first auxiliary shaft drives a pulley t on the second auxiliary shaft located under the feed-

Fig. 3

rolls. On the right-hand side of the machine, a gear on the second auxiliary shaft drives a gear t_1 on the first bottom feed-roll shaft, which in turn drives a gear t_2 on the rear top feed-roll shaft. On the left-hand side, but not shown in Fig. 3, a gear on the end of the second auxiliary shaft drives a gear on the rear bottom feed-roll shaft, which in turn drives a gear on the first top feed-roll shaft.

The feed-apron k is driven by means of a gear on the bottom feed-roll shaft on the opposite side of the machine, from that shown in Fig. 3 which drives a gear on the

apron-roll shaft through a small intermediate gear on a stud. There is about $\frac{1}{2}$ inch space between the apron and the feed-roll, which allows heavy foreign materials to drop to the floor so as not to enter the picker. Both the front and the rear top feed-rolls are controlled by levers *m*, one on each side of the machine, on which weights *n* are fastened; these give the rolls a little play, or up-and-down motion, to allow for bunches in the stock and for irregular feeding.

The picker cylinder of this machine is composed of three iron spiders *l* fastened on the main shaft, to which are dovetailed six steel lags l_1. Flat steel teeth are dovetailed with the lags, doing away with setscrews for fastening them. The main shaft is equipped with tight and loose pulleys, or with a tight pulley on each side for double driving, which is advisable with the wider machines.

The grate under the picker cylinder may be drawn out on a slide for cleaning. The space under the grate is cleaned from either side by the removal of panels *p*.

26. Operation.—In operation, the stock is fed on the slatted apron *h* either by hand or by an automatic feed and is delivered to the first pair of feed-rolls j_1, which holds the wool while the second set j_2, running one-third faster, combs and opens it out.

The advantage of a double set of feed-rolls with a draft between them is that the stock is more thoroughly opened, straightened, and mixed than by the ordinary picker with a single pair of rolls; and it is also impossible for bunches of stock to pass directly to the cylinder and the fibers to become broken by being opened too quickly, as the first pair of rolls holds the stock while the second pair, running faster, gradually opens it out and pulls it apart. This insures a thorough opening and mixing of the stock with very little liability of injury to the fiber. The stock is next delivered to the picker cylinder, which revolves downwards and beats the wool over the grate, finally delivering it through a trunk to the gauze room.

POINTS IN MANAGEMENT

27. Pickers require frequent cleaning and should never be allowed to become clogged with gummy grease, as will happen if they are not cleaned between different lots of stock operated on. The cylinder of the picker should be examined frequently for loose or broken teeth, which should be tightened or replaced at once since they reduce the efficiency of the machine; the picker-cylinder bearings should be oiled at least twice a day, as they are very apt to heat, owing to the high speed and the weight of the cylinder. A 36-inch picker may be run at 1,000 revolutions per minute, but the wider machines, as for instance, the 48-inch, should not make more than 800 revolutions per minute. These speeds may be regarded as maximum speeds, and it will be found that a picker will give longer and more satisfactory service if driven somewhat slower. For the best results it will be found advantageous to feed the picker somewhat light rather than to have bunches of stock to open out on the card.

The heavy cylinder of a picker armed with strong, sharp teeth and rotating with great velocity is a source of great danger, and many accidents occur owing to carelessness and neglect of even ordinary precaution. A good rule to follow is never to remove the bonnet or to take out the grate while the cylinder is in motion. When cleaning the cylinder or the grate underneath, the bonnet may be lifted and a stout stick or an iron bar thrust through the cylinder to prevent any one from unwittingly starting the machine while it is being cleaned.

FEARNAUGHT

28. While this machine is used for the same purposes as a mixing picker, it is entirely different, both in principle and construction. The principle of the Fearnaught may be considered as that of opening the wool by means of a large rotating cylinder filled with cockspur teeth, which work in conjunction with similar teeth placed in smaller rolls arranged over the large cylinder. The combined action of the

cylinder and smaller rolls, which are known as workers, is to separate all bunches of wool and to intermix the fibers thoroughly.

29. Construction.—While wood enters to a larger extent in the construction of a Fearnaught than of a mixing picker, this is not objectionable, since the slower speeds of the parts of this machine render them less liable to cause fire than the rapidly rotating cylinder of a mixing picker. As shown in Fig. 4, the feed-apron h is of the usual construction; the iron feed-rolls j are filled with intersecting cockspur teeth and are self-cleaning. The main cylinder l and

FIG. 4

workers l_1 are of wood and are filled with cockspur teeth forged from square steel rods and firmly driven into the wood. The machine is usually constructed with four workers. In order to keep the workers clear of wool, a stripping roll, or stripper, l_2 works in conjunction with each worker. The strippers are filled with teeth similar to those in the main cylinder and workers except that they are straight. Owing to the strain of opening the wool, the

workers must be driven with a chain, but the strippers, as they are subjected to but little strain, may be driven with a belt. There is a beater, or fan doffer, *m* (similar in construction to the beater shown at *f*, Fig. 6) at the rear of the machine. This takes the stock from the main cylinder and throws it out of the machine.

30. Operation.—In operation the stock is spread evenly on the traveling feed-apron and is taken by the cockspur feed-rolls, which hold it as it is combed out by the main cylinder. The cylinder then brings the stock under the action of the workers, and the passing of the teeth on these rolls between those on the cylinder results in the wool being thoroughly opened and combed out. The strippers take the stock from the workers and pass it back to the main cylinder, which besides opening out the wool in conjunction with each of the workers acts as a carrier, conveying the stock from the feed-rolls to the fan doffer. The doffer takes the stock from the main cylinder and by virtue of the current of air that it generates, delivers it through a trunk to the gauze room.

31. The Fearnaught is an excellent machine for opening and mixing wool, doing its work with no perceptible injury to the fiber. Its gentle action is due to the principle of its construction and the comparatively slow speeds of its moving parts.

A Fearnaught with a cylinder 36 inches in diameter should make about 225 revolutions per minute; one having a cylinder 48 inches in diameter should make 175 revolutions per minute; while a cylinder 55 inches in diameter should not have a speed of more than 100 revolutions per minute. Its capacity varies, according to its size, from 800 to 1,500 pounds of wool per hour. The machine is built in three widths—36-inch, 40-inch, and 48-inch—having cylinders 36 inches, 48 inches, and 55 inches in diameter, respectively. The 48-inch machine is used for carpet wools and long worsted stock.

THE BRAMWELL AUTOMATIC PICKER FEED

32. The object of automatic, or self-feeding, devices is to deliver the stock to other machines evenly and uniformly and at the same time to allow the operator to care for a maximum number of machines with a minimum amount of

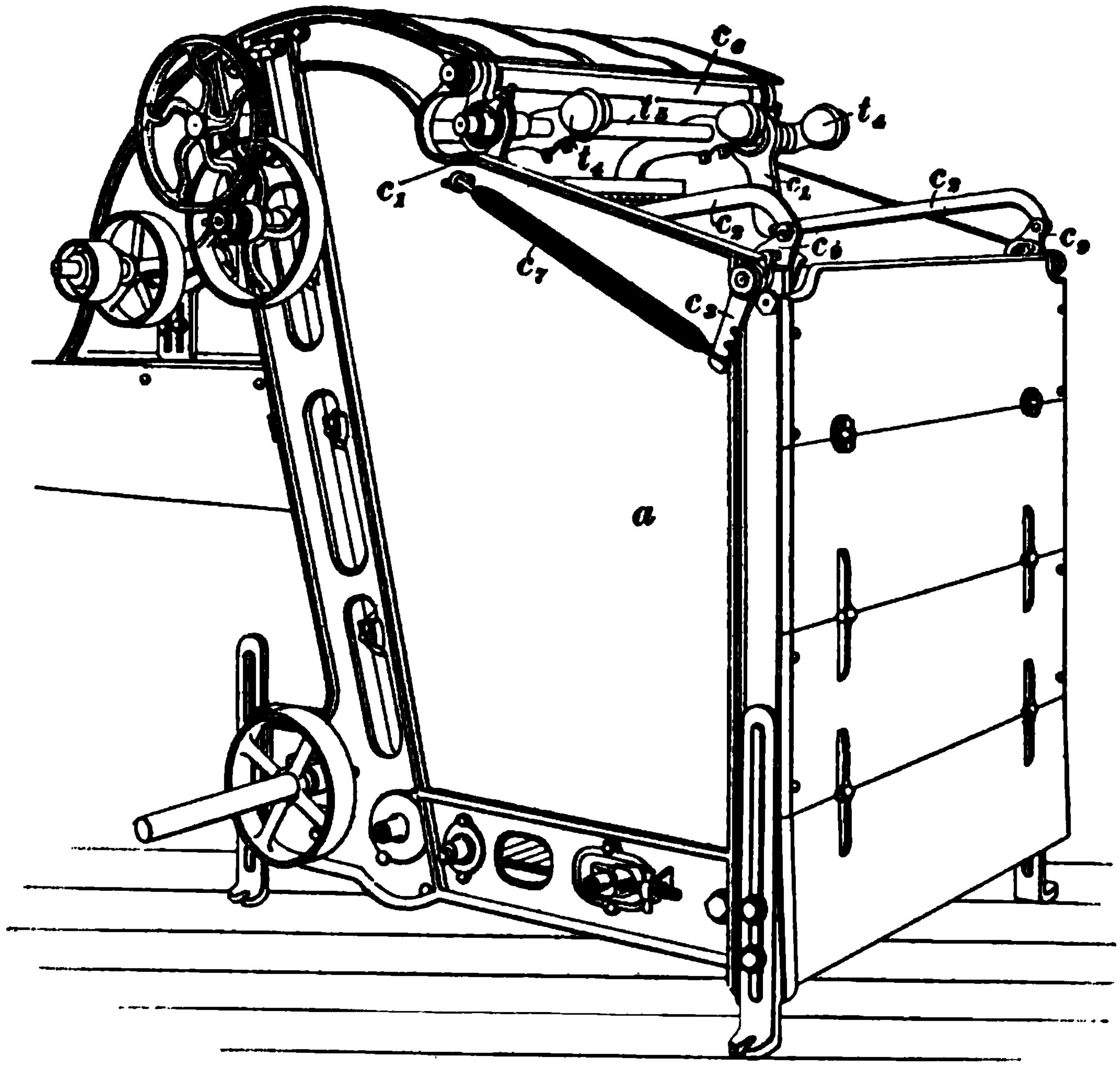


Fig. 5

labor. The general features of the Bramwell self-feed as adapted for feeding mixing pickers, burr pickers, dusters, and similar machines are shown in Figs. 5 and 6, the latter being a sectional view and showing the machine as connected with a mixing picker.

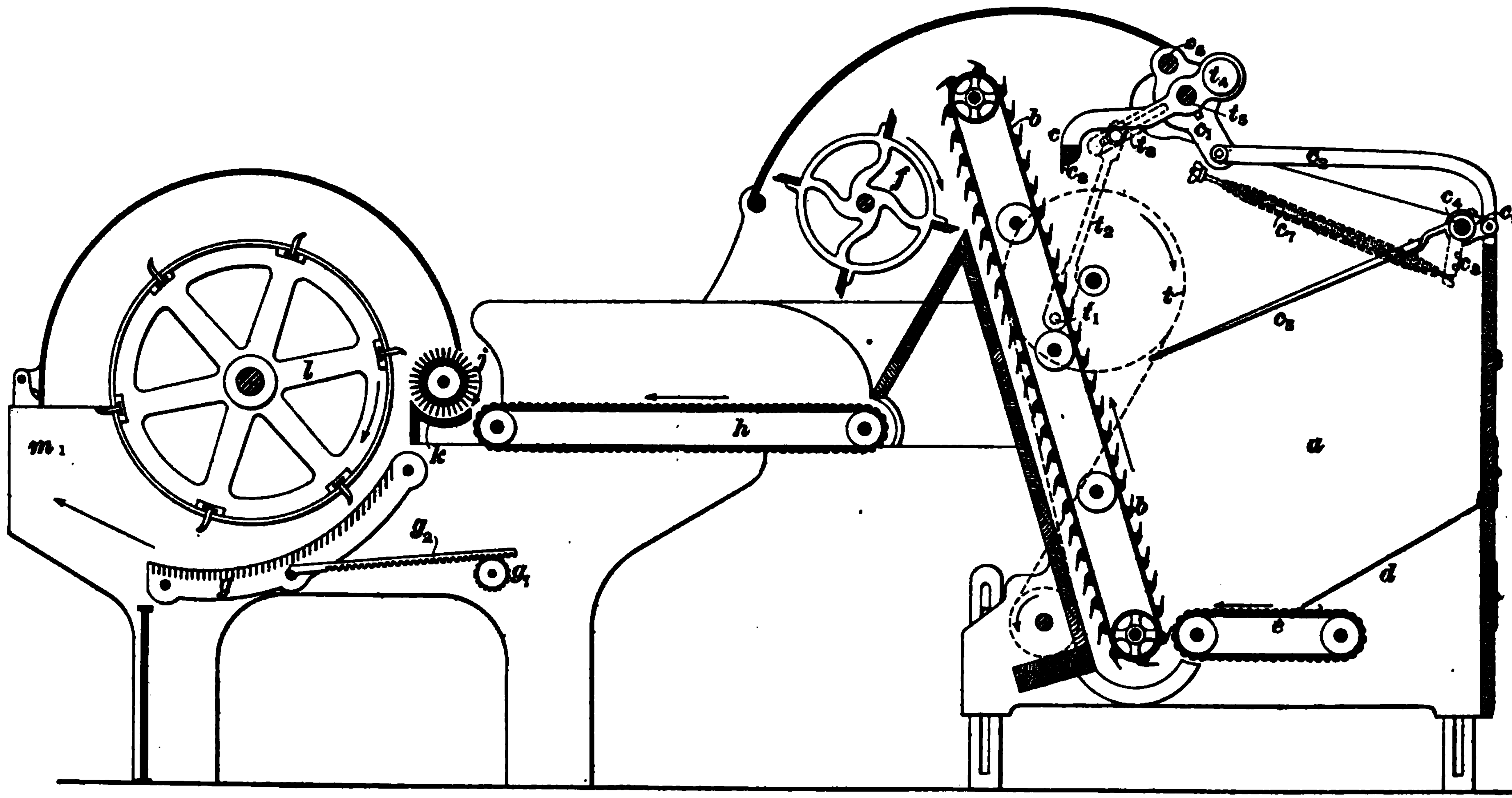


FIG. 6

33. Construction.—As shown at Fig. 6, the machine consists primarily of a large feed-box, or hopper *a*, which the operator keeps supplied with stock. At the rear of the hopper is an endless apron *b*, called a lifting, or elevating, apron. This apron, which travels in the direction indicated by the arrow, is provided with a series of slats fitted with sharp spikes about an inch in length and inclined forwards in the direction in which the apron is traveling. The apron extracts the stock from the hopper and carries it to a beater *f*. This beater strikes the wool from the apron and deposits it evenly on the feed-apron of the machine to which the feeding machine is attached. The amount of stock carried by the lifting apron is regulated by an oscillating comb *c* that strikes off all large bunches of wool that the apron extracts from the hopper, thus rendering the apron more evenly loaded and the feed more regular. The greater part of the machine is of iron, but the rear end of the hopper is boarded up, provision being made by means of hinges and iron buttons for removing the boards, so that the hopper may be brushed out when the machine is cleaned. At the bottom of the hopper there is a traveling apron *e* for the purpose of keeping the stock in the hopper in contact with the lifting apron at all times. Both this apron and the lifting apron are constructed of hardwood, half-round slats riveted to leather belts. There are adjustments on the wooden rolls on which these aprons run by means of which the aprons may be tightened in case they grow slack from wear or stretching. In the lower part of the hopper there is also a tin slide *d*, placed at an angle of about 30° with the bottom of the hopper and sloping downwards toward the lifting apron. This slide causes the wool to move forwards to the traveling apron, so that when the machine is allowed to run empty no stock will remain in the hopper. The beater is constructed with four blades having strips of leather attached; these sweep the stock from the spikes in the elevating apron without in any way injuring the wool. There are adjustments on the bearings of the beater by means of which it may be set nearer to or farther from the lifting apron as occasion demands.

The self-feed is usually driven from the main shaft of the mixing picker, when connected to that machine, with a cross-belt and is provided with tight and loose pulleys on the shaft at the bottom of the machine. The driven pulleys are not shown in Fig. 5. There is a belt shipper so arranged that the feed may be stopped from either side of the machine. The beater is driven by a cross-belt from the lower, or main, shaft of the feeder. The lifting apron is driven from a pulley on the main shaft, which drives a pulley on a stud with a crossed belt. Fastened to this pulley is a small gear, which is the change gear for the speed of the aprons, an increase of its size giving a greater speed to the lifting and traveling aprons and a heavier feed to the mixing picker. The change gear, as shown at Fig. 5, drives a large gear on the shaft of the top lifting-apron roll, which carries the apron. On the opposite side of the machine the traveling apron is driven from the shaft of the bottom lifting-apron roll by means of a short train of gears connecting with the front roll of the traveling apron.

The oscillating comb c, Fig. 6, is driven from a pulley on the main shaft of the machine, which drives the pulley t on a stud; on this pulley there is a crankpin t_1 to which a connecting rod t_2 is attached; the latter is also connected with an arm t_3 attached to the comb shaft t_5. There is a slot in this arm, which admits of changing the position of the connecting-rod, thus varying the throw of the comb. Weights t_4 are attached to the comb in order to balance it, so that its motion may be more regular. The comb is provided with triangular teeth c_6, which comb off the excess of stock that is extracted from the hopper by the lifting apron.

34. Comb Regulating Device.—There is a device for regulating the proximity of the comb to the lifting apron by means of which, if the wool is nearly exhausted from the hopper, the comb is moved from the apron and less wool struck from the lifting apron. This makes the feed uniform whether the hopper is full or nearly empty. If such an arrangement were not provided, a large amount of the wool

would be passed forwards when the hopper was full and a small amount when nearly empty.

The principal parts involved in this device are suspended from a fixed shaft c_6, Fig. 6, by means of arms c_1, one on each side of the machine. These arms, with the shaft t_2, can be pushed nearer to the lifting apron, thus reducing the distance between the comb and the apron, or drawn farther away, thus increasing the distance, by means of the horizontal curved arms c_2, of which there are two (one on each side of the machine) attached to the lower ends of the arms c_1.

The comb arms c are attached to the central shaft t_2, to which is also attached the arm t_3 on the outside of the machine, which receives an oscillating movement from the pulley and crank arrangement shown by the dotted lines. This oscillating motion of the comb, however, has nothing to do with regulating its distance from the lifting apron, which is governed by means of a comb regulator, or finger rack, c_3. The normal position of the rack is very nearly at right angles with the lifting apron when the hopper is empty, it being held in that position by means of two springs attached to short arms c_5 fastened to its shaft c_4, one on each side of the machine, the spring shown being marked c_7. The tension of these springs may be regulated by means of thumbscrews. When the hopper is filled, the wool is thrown on the top of the rack, pressing it downwards until it is forced against the back of the hopper into an almost vertical position. The rack is attached to the shaft c_4 and, by means of short arms c_9, is pinned to the curved ends of the rods c_2 that operate the ends of arms c_1.

As the lifting apron extracts the stock, the amount remaining in the hopper will be diminished and, consequently, the pull of the springs c_7 will raise the finger rack as fast as the weight of the stock in the hopper is decreased. The motion thus imparted to the shaft c_4 will move the levers c_9 backwards and, by means of the connecting-rods c_2, the levers c_1 will be drawn in the same direction. Since the comb is supported by arms attached to the shaft t_2, which is carried by the levers c_1 fulcrumed on the fixed shaft c_6,

the upward motion of the finger rack will draw the comb from the lifting apron, which will result in less wool being struck from the apron. When the hopper is refilled, the rack will be pressed down again by the weight of the stock, thus moving the comb nearer to the lifting apron so that there will be no increase in the amount of stock passed forwards to the picker in consequence of the hopper being full. By this means the feed is kept uniform without regard to the amount of stock in the hopper. The comb should not be set too close to the lifting apron and the latter should be allowed to carry a fairly heavy feed, except on fine stock.

35. Operation.—The self-feed and mixing picker shown in Fig. 6 operate as follows: The hopper *a* of the self-feed being supplied with wool, the spikes on the lifting apron *b* extract an amount of stock in excess of what is required. This excess of stock being struck off and the feed kept uniform as explained, the apron conveys the wool to the beater *f*, which sweeps off the stock and drops it on the feed-apron *h* of the picker. The stock is then delivered to the feed-roll *j*, which, working in conjunction with the concave dish *k*, passes the wool to the picker cylinder *l*, the stock being finally passed in an open and lofty condition to the gauze room through the trunk at m_1.

The feed requires very little extra power, possibly ·2 horsepower for the largest machine when feeding heavy. With smaller machines and lighter feeds, the horsepower required will be correspondingly reduced.

WOOL OILING

LUBRICATION OF WOOL

1. Object of Oiling Wool.—Owing to the removal of the natural, preservative, greasy matter, or yolk, by the scouring, it is necessary to lubricate the fibers of wool with oil before carding and spinning, in order to preserve the serrations of the fiber from injury during the carding process. At the same time, oiling wool enables it to be worked with the least waste possible in the carding and to be spun into the finest yarn possible consistent with the quality of the stock. Also, the natural elasticity and softness of the fiber are uninjured if the stock is lubricated and the oil used is suitable for applying to wool. The oiling of wool before carding and spinning, therefore, is an important process and should be carefully done, not only with regard to the kind of oil used, but also with regard to the quantity used and method of application. Imperfect oiling results in gummed-up cards, uneven work, and also in the destruction to a greater or less extent of the elasticity of the resultant yarn.

Especial care should be taken with the wool for cloth that is to be heavily milled; the oil used for such stock should be pure and one that easily saponifies, thus aiding in the fulling and scouring of the cloth. Impure oil or oil that will not saponify easily will make the dyeing streaky and uneven. If oil is not applied in suitable proportions to wool that, when made into cloth, must be fulled, there is danger of impairing the felting properties of the fiber by injuring the serrations of the fiber. The oiling of wool also lessens the amount of flyings from the cards, and consequently the percentage of waste.

LUBRICANTS

2. Among the oils used for lubricating wool may be mentioned *olive oil*, *lard oil*, *oleine*, and *red oil*.

3. Olive Oil.—Although universally acknowledged to be the most suitable for applying to the wool fiber, **olive oil** is only used on the finer and more expensive grades of stock, owing solely to its cost. The olives, which grow in warm countries, chiefly in California and in Southern Europe, are collected when ripe, and ground into a pasty mass and pressed. The oil obtained from the first pressing is called *virgin oil*, and is colorless; it is principally used for table purposes. The material, however, is not exhausted by the first pressing, but is treated with hot water and further pressed. The oil obtained by the second pressing is of a fine yellow color and is the olive oil commonly used for lubricating wool before carding and spinning. By a third pressing of the ground olives, an inferior oil is obtained, which is used in making soap. The specific gravity of hot-pressed olive oil is about .92.

The best olive oil for wool is that known as *Gallipoli*, but many other olive oils are used, the only precaution necessary being to obtain an oil that is free from impurities. Olive oil is often adulterated with cottonseed oil, and the difference between the pure and impure article can be detected only by an expert.

For the finer grades of woolen goods, olive oil is often used, since it enables the stock to be carded with the least waste and spun to the finest counts. Olive oil softens the stock and preserves the natural serrations of the fiber from injury during the carding process, and even after lying in an oiled state for a long time, the fiber will not become hard and stiff nor the oil rancid or stale, provided that the oil used is pure.

When using olive oil on wool, a good proportion is 6 quarts per 100 pounds of wool; this, of course, may be varied to suit different cases. As a rule, dyed wools require more oil

than white wools, especially those dyed dark shades. The oil should be mixed with enough hot water to form an emulsion of sufficient quantity to be applied to the entire lot of wool. All kinds of oils are usually applied in the form of an emulsion, which is merely a mechanical mixture of oil and water in which the oil exists in a state of the finest division and is particularly well absorbed by the wool fiber. In order to make this emulsion, it is necessary to add some substance that will enable the oil and water to unite, or, to use a common expression, *cut* the oil. There are two substances used for this purpose—ammonia and borax. The former is preferable on account of its volatile nature, but the latter, also, is quite extensively used.

In making emulsions the best method is first to add the substance that aids the water and oil to unite (either ammonia or borax) to the heated water and then gradually add the oil, stirring well until a milky solution is formed. By dipping the fingers into this solution and rubbing them together, it is easily determined whether the emulsion contains sufficient oil and is therefore greasy enough.

An emulsion of olive oil for fine wools that has been found to give excellent results is made as follows: To 10 quarts of hot water add a cupful of ammonia, and to this add 6 quarts of pure olive oil. This will be sufficient for lubricating 100 pounds of wool.

For fine wools, and in cases where the yarn is going to lie for a considerable time before being woven, it is always well to use olive oil, as this will keep better in the yarn than any of the cheaper oils, being less liable to grow rancid or gummy.

4. Lard Oil.—The most common lubricant used in connection with wool is **lard oil,** which is applied in varying proportions according to the condition of the wool that is being worked. If the stock is very dry or harsh, more oil is required than if the scouring and drying had been properly performed and the wool were soft and contained just enough natural lubricating matter. When of good quality, lard oil

is all that can be desired for an ordinary quality of wool. While not so desirable as olive oil for the finest classes of wools, it meets all the requirements of a good lubricating agent for medium wool without being so expensive as olive oil. In regard to the quality of the lard oil to be used, it may be stated that it varies according to the stock in hand. For wool well scoured and dried about 5 quarts of oil and 5 quarts of water are used to 100 pounds. This may be reduced to 4 quarts of oil if the wool is quite moist and soft, or increased to 6 quarts if the stock is harsh and brittle.

In making the emulsion, take the boiling water and add to it about 1 ounce of borax or a cupful of ammonia; the latter is to be preferred on account of its being volatile and not remaining on the wool. To the solution of water the oil should be added slowly, with constant stirring, until a milky emulsion free from bubbles is formed.

Another recipe for a lard-oil emulsion is as follows: Best lard oil, 4 gallons; water, 5 gallons; borax, 4 ounces. Dissolve the borax in a little warm water and then add the solution to the boiling water; agitate, and then gradually pour in the oil, constantly stirring. Boil a few minutes and the emulsion is ready for use.

For ordinary stock, 16 per cent., by weight, of this solution will be found to be about right, but it must be remembered that no hard and fast rule regarding the amount of lubricating matter to be used on wool can be given. Much depends on the condition of the wool, either naturally or as a result of the scouring or drying, which may injure the wool so that it will require much more oil than would otherwise be sufficient.

5. Oleine.—Another substance that is used quite extensively for lubricating wool is known as **oleine.** It occurs as a by-product in the manufacture of stearine candles, and when free from impurities, is an excellent substance for the purpose. In the process of making stearine candles, stearine and oleic acid are produced, and the stearine is afterwards freed from the oleic acid by means of sulphuric acid. Oleine is a product obtained from the oleic acid, but the sulphuric

acid that was used to free the stearine from the oleic acid should be removed by distillation, as if present it injures the card clothing.

Oleine, when employed for lubricating wool, is used in varying proportions according to the stock in hand, a good proportion being 4 parts of oleine, free from acid, to 6 parts of water. Add a little ammonia or borax to aid the oil and water in uniting and use from 20 to 25 per cent. of the weight of the wool. If the stock is dyed dark colors or heavily weighted with any dye stuffs, it is a good plan to use less water and more oil.

Another good emulsion may be made with 10 per cent. oleine and 15 per cent. water of the weight of wool to be oiled. The water should be hot and the borax or ammonia added to it, in order that the oil and water may unite. For wools that are dyed dark colors and heavily weighted with dye stuff, 10 per cent. of water will be sufficient.

6. Red oil is practically the same as oleine and, like it, is liable to contain free acid. There are two kinds of red oil in the market—the saponified, or ordinary red oil, and the distilled, or oleine, oil. The former is not generally considered as suitable for oiling wool as the latter.

In the preparation of the saponified oil, the tallow or grease is treated to a jet of live steam, and after a certain period breaks up into stearine and oleic acid. The material is now placed in bags and the oil pressed out. Red oil obtains its red color from the iron in the presses, which becomes rusted and stains the oil.

7. Mineral oils are frequently used for oiling wools and are preferred by some manufacturers; but they are more difficult to remove from the yarn or cloth by scouring, as they do not easily emulsify. In the presence of some saponifiable oil, such as lard oil or olive oil, mineral oil appears to emulsify more easily and for this reason is often used mixed with lard oil, with which it is easily scoured from the cloth or yarn.

TESTS FOR OIL

8. Oleine is sometimes sold under the name of *elaine oil*, both oils having the same composition and both being liable to contain sulphuric acid; in fact, they are rarely free from acid, the commercial oil containing usually at least .5 per cent. of acid and sometimes a great deal more than this. If acid is present in any great quantity it will attack the card clothing during the carding of the stock, and if the oil is regularly used, will in time destroy the wire. The acid also burns the hands of the operatives if much is present.

A good test for the presence of acid in oil is to place a drop of the suspected oil on blue litmus paper; if a red color is immediately developed, acid is present. This test, however, does not give any idea of the amount of acid present, since the least amount will turn the litmus paper red. A better way to test the acid in oleine is by means of the hydrometer. The specific gravity of pure oleine is about .91, but if it contains acid, the oil is heavier in proportion to the amount that it contains.

Another test for a good oil for wool is as follows: Take two parts of a solution of sodium carbonate 3° Baumé and add to it three parts of oil. If, on stirring, a milky solution free from bubbles is formed, without oily drops on the surface, it is an indication of good lubricating qualities.

It is of the greatest importance that a suitable oil should be selected for oiling wool. The use of cheap oil is false economy, owing to the increased amount of waste in the carding and spinning and the decreased production and quality. The price of the oil used is cheap compared with the cost of the wool, and the amount used should not be stinted any more than the quality.

The following characteristics should be possessed by an oil that is suitable for lubricating wool: It should be readily emulsified by an alkali, in order to be easily removed from the yarn or cloth by scouring; it must not be oxidized by exposure to the air nor become rancid; and

it should be free from mineral acid, sulphuric acid being present in low grades of oleine. An oil for oiling wool should also be devoid of color and smell, as far as possible, and must not stain the wool.

METHODS OF OILING

OILING BY HAND

9. There are many methods and means of applying the oil to wool, the oldest, the most used, and the one considered by the majority as the best being the method of oiling by hand. If oil is unevenly distributed over the stock, the result will be noticed in the carding and spinning. Some fibers of the stock will be barely touched by the oil, while others will receive more than their due proportion, which, with the refuse material often found on dyed wools, will form a coating completely covering them. This will harden gradually and affect the pliability of the fiber. The poorly oiled fibers exert a controlling influence and the result will be a general deterioration (as when shoddy is mixed with wool); thus, the more even the distribution of the oil, the more nearly perfect will be the resulting yarn.

In former times, the oiling of the wool was usually attended to by the boss carder himself. He removed his shoes and stockings and taking a pail of warm oil walked from right to left over the thin layers of wool on the floor, distributing the oil by dipping his hand into it and then shaking it from his fingers as he passed slowly along. Each layer of wool was whipped with poles, after the application of the oil, to mix thoroughly the oil with the wool. This is the method employed in many mills today, with the exception that, instead of sprinkling the oil with the fingers, a can resembling a garden sprinkler is used. This can is provided with a T-shaped nozzle pierced with several rows of holes.

Suppose that 10 quarts of emulsion is to be applied to 100 pounds of wool. The emulsion should be prepared first;

then 10 pounds of wool should be spread evenly on the floor in a thin layer and 1 quart of oil sprinkled over it as evenly as possible. This layer of wool should be whipped, or beaten, with a long pole in order to distribute the oil as evenly as possible throughout the layer of wool. This operation is repeated ten times, each layer of wool being placed on top of the preceding one, oiled, and beaten until the 100 pounds of wool are used up and the 10 quarts of emulsion applied.

When using the sprinkling can in oiling a lot of wool, the oil should be distributed as evenly as possible and care should be taken not to apply a double supply to any one portion of the stock. The whipping, or beating, of the layers of wool should be thorough, as on this depends, to a great extent, the equalizing of the distribution of oil.

The stock is run through the mixing picker once or twice and is then ready for the cards, but it is well to let oiled stock lie for a short time, say over night, in order to allow the oil to penetrate the fibers. Stock oiled with lard oil, however, should not remain more than 48 hours between oiling and carding, or the carding properties of the wool will be impaired owing to the stiffening of the fiber and oxidizing of the oil.

In oiling all-wool mixes, each layer of material is sprinkled as it is laid down and is then beaten with poles. In cotton and wool mixes, however, the wool is oiled separately and the stock is carded as soon as possible after mixing, so that the cotton will not absorb the oil from the wool, in which case the cotton is much more difficult to card, having a tendency to become stringy and bunch up.

The same plan is followed with wool and silk waste mixes as with wool and cotton. The silk, being especially hard to work, needs extra carding and should be run through a card previous to mixing. In order to get rid of the electricity, which is troublesome in carding, silk may be dampened by lying under wet burlap over night, being mixed with the oiled wool and carded in the morning.

When shoddy has been lying around for some time and is very greasy and gummed up, it is well to use a large proportion of water and a small proportion of oil in the emulsion that is used for lubricating.

AUTOMATIC OILERS

10. Although in many mills the old method of hand oiling prevails, there are some mills that use automatic oilers, of which there are several makes designed to oil the stock at various points in the process of manufacture. The work of any of these devices is not absolutely what could be desired, but they furnish a means of oiling a maximum quantity of stock with a minimum amount of trouble and at the least expense.

11. Spencer Oiler.—This machine is designed to lubricate the wool, noils, or other stock as it passes into the mixing or burr picker, being attached to the mixing picker in most cases. The object of the oiler is to do away with the manual labor of lubricating wool and perform this operation in connection with the picking. At the same time it is designed to apply the oil evenly and uniformly to the stock and to effect a saving in oil, which is often wasted in large amounts when the oiling is performed by hand.

The principle on which this device is based is that of applying the oil to a rotating brush into the bristles of which a stationary blade or knife is set. The rotating brush striking against this knife throws the oil in a fine spray on the wool, which is evenly spread on the feed-apron of the picker.

The partly assembled parts of the Spencer oiler are shown in Fig. 1. It is practically impossible to show this machine set up as in operation, because the connections, etc. of such a machine as an oiler must necessarily vary to suit different circumstances and the needs of different mills. The large tank *a* that contains the supply of oil or emulsion is often located some distance from the picker where the wool is oiled, or it may be placed on the floor beside it.

As shown in Fig. 1, the oiler consists of an arch-like frame that, when attached to the frame of the picker, spans the feed-apron and carries the various parts of the machine, with the exception of the oil tank and pump, which are usually placed on the floor. The essential features of the machine

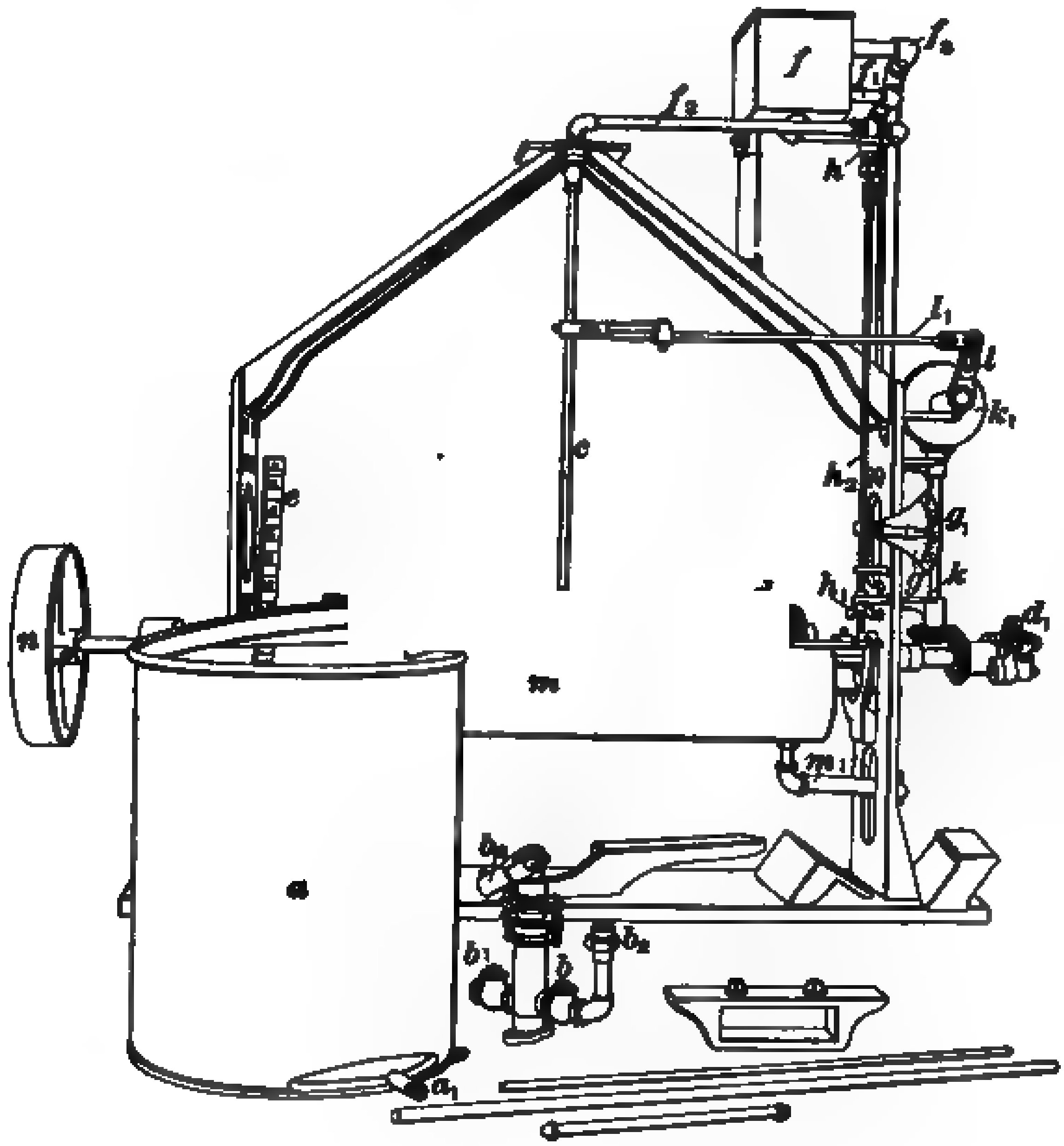


FIG. 1

are the supply tank *a* for holding the oil, the pump *b* and oscillating pipe *c* for supplying the oil to the brush *d*. The knife blade working in connection with the brush is hidden from view in the figure.

The supply tank is of sufficient size to hold the oil for a large batch of wool. It is provided with a float to which the

gauge e is attached and by means of which the amount of oil or emulsion that the tank contains can readily be ascertained at any time.

12. When the various parts of the oiler are set up for operation, the feedpipe b_1 of the pump is connected to the delivery pipe a_1 of the supply tank. The delivery pipe b_2 of the pump is connected with the pipe f_1 that opens into the reservoir f. The pump is driven by means of the crank d_1 on the shaft of the rotating brush, which by means of a suitable rod is connected with the plunger of the pump at b_3. In operation, the pump takes the oil from the supply tank and forces it to the reservoir f through the pipe f_1. The oil flows by gravity from this reservoir through a stationary pipe f_2, and by means of an oscillating pipe c is applied evenly to the rotating brush that extends across the feed-apron of the picker, 2 or 3 inches above the wool spread thereon. The brush rotates rapidly, and, being charged with oil from the pipe c, throws the same on the wool on the feed-apron of the picker when the bristles strike the knife blade that is set into them. The oil is thrown on the wool in a fine spray, and as the stock passes through the picker, the oil is thoroughly mixed with the fibers. A trough m collects the oil that does not fall directly on the stock, and through suitable connections with the pipe m_1 returns the same to the supply tank. The oscillating motion of the pipe c is obtained by means of a crank l, which is connected to it by means of a rod l_1. Motion is imparted to the crank by means of a gear k_1, which is driven from the brush shaft through bevel gears and an upright shaft k. The oscillating pipe should not swing quite the entire length of the brush, for if it does, there is a liability of the ends of the brush receiving more oil than the central portion, and consequently of the wool on the sides of the picker being more heavily lubricated. The amount of oscillation may be regulated by moving the connecting-rod l_1 in the slot of the crank l. The reservoir on the top of the machine is supplied with an overflow pipe f_3

that connects with the supply tank on the floor. Thus there is no danger of an overflow if the delivery of oil is shut off and the pump left running.

The amount of oil supplied to the brush is regulated by means of the supply valve *h*, which may be set to deliver any desired amount by means of a pointer g_1 that operates the rod h_2 connecting with the valve. This rod may be locked in the desired position by means of a thumbscrew h_1. The amount of oil supplied to the brush is indicated by the pointer g_1 on a dial *g*.

The pump may be set for a different length of stroke by means of a slot in the crank-arm that drives the same. The stroke of the pump should be so adjusted that there will be a very small stream running down the overflow pipe f_2 when the oiler is spraying the largest amount of oil that will ever be required. This keeps the oil in constant motion, which is an important point when applying emulsions, since they are liable to become separated into their component parts if allowed to stand.

To regulate the amount of oil per hundred pounds of wool, place in the tank only the amount of oil required for the batch of stock that is to be run through; set the valve so that when one-fourth of the batch is run through, the tank gauge will show that one-fourth of the oil or the emulsion (as the case may be) is applied, and when one-half of the lot has passed through the picker, one-half of the oil is used, and so on, until by experience the exact place to set the pointer on the dial to use a given amount of oil for a given amount of stock is found.

The rotating brush and knife blade should be as level as possible each with the other, so that the oil will not run off to the side of the knife blade, which should be set at an angle of about 45° into the brush to throw a fine spray of oil. The knife blade should be set into the brush about $\frac{1}{4}$ inch. In order to attain the most perfect results, the oil or emulsion in the tank should be heated with steam pipes, as better results in oiling are always attained when warm oil is applied.

The power is applied to the machine by means of a pulley *n* on the shaft of the brush, which may be driven either from the main shaft of the picker or from the shaft of the beater on the self-feed.* To attain the best results, the brush should make about 60 revolutions per minute.

13. Sargent Oiler.—Another machine for automatically oiling wool is shown in Figs. 2 and 3, its object being to lubricate the stock as it passes into the feed-rolls of the first breaker card. The oil is broken into finely divided particles, as is the case with the oiler previously described, and precipitated on the wool, which is evenly spread on the feed-apron of the card. The principle on which this machine depends is that of an oscillating, instead of a rotating, brush that extends across the feed-apron and, being moistened with oil, throws the same on the stock.

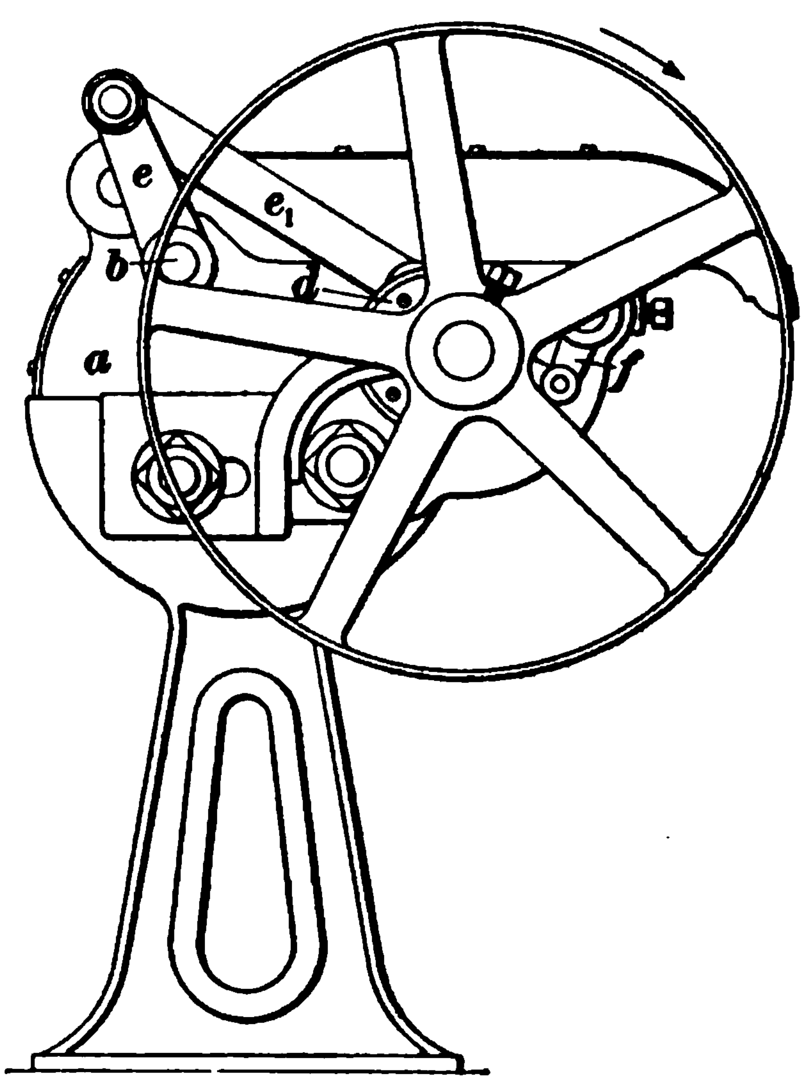


FIG. 2

The machine consists of two stands that carry an oil tank *a* stretching across the feed-apron of the card, and also carry the driving parts of the machine. The tank has a capacity of about 4 gallons of oil or emulsion, and contains a dipper shaft *b*, which carries a dipper b_1; this brings the oil from the tank to the vibrating brush *c*.

The driving pulley of the machine is fastened to a short shaft, which carries an eccentric *d* on its opposite end. A lever arm *e* on the dipper shaft is connected to a crankpin on the side of the eccentric by a connecting arm e_1, by means of which the dipper is given an oscillating motion, bringing

the oil from the tank and depositing it on the oscillating brush, which is driven by the eccentric through the arm *f*.

The amount of oil deposited on the stock depends on the speed of the machine. The driving pulley should make about 30 revolutions per minute for coarse stock, which passes through the cards rapidly. For fine stock, which goes

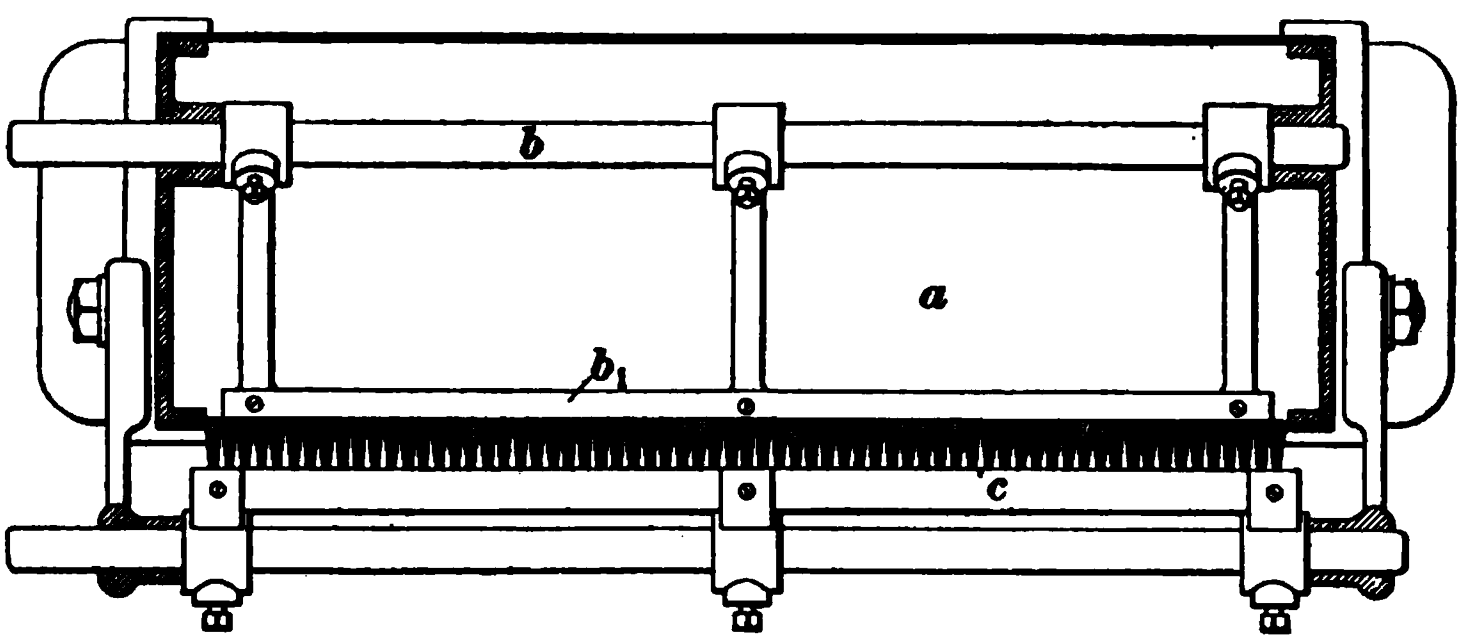


FIG. 3

more slowly, about 20 revolutions per minute is sufficient. The amount of oil used per hundred pounds of stock with a certain speed can only be determined by experiment. The machine is driven from the first worker shaft of the card.

The advantage of oiling the stock at the first breaker card is that there is but little chance for evaporation, as the wool is only exposed to the air after lubrication in passing through the cards. This is especially advantageous if emulsion is used, as an emulsion evaporates faster than pure oil. Another advantage of lubricating the stock at the first carding process is that large lots of wool or mixes can be picked beforehand and kept in reserve for the cards, there being no danger of injury by rancid or gummy oil.

The great disadvantage of this oiler is that as the oil tank gets empty, the amount of oil deposited on the stock is reduced because the dipper will not bring up as much oil to the vibrating brush. If more oil is required than is being supplied to the stock, the machine must be speeded up by increasing the size of the driving pulley on the worker shaft.

14. Goddard Oiler.—By referring to Fig. 8, *Burr Picking*, it will be noticed that there is located over the outlet spout of the burr picker a square box-like device, which is a form of automatic oiler, called the **Goddard oiler.** This consists of a case with a revolving brush inside and an oil tank that rests on the top of the case, in which oil or emulsion is placed and fed through a faucet and tube into the oiler case containing the revolving brush. The oil is brushed across an oscillating bar and thrown as a fine spray over the wool as it leaves the burr picker.

The amount of oil is easily regulated by the faucet; still there is some difficulty in knowing just how much oil is being used per hundred pounds of wool. Another fault with this method of oiling is that the stock can be picked only as it is needed by the cards, because it will not do to let oiled stock lie around, owing to the fiber becoming stiff and the oil gummy.

WOOLEN CARDING

(PART 1)

INTRODUCTION

1. Condition of Stock.—In order that the best results may be obtained in **carding**, the preparation of the stock in previous processes and by the preparatory machines must be thorough. The wool must be well scoured and dried and the fiber soft and pliable. Harsh-feeling stock that has been injured in the washing and drying processes will not card well, nor is it possible to spin a fine, elastic yarn from such material after it is carded. Such stock will also have a tendency to make an excessive amount of waste owing to the flyings, which cannot be wholly avoided in carding and the amount of which increases as the quality of the stock deteriorates. *Flyings* are the short, fluffy fibers that are thrown from various machines, particularly the cards, owing to the rapid rotation of certain parts of the machine.

In order to card well, the stock must be well burr-picked or carbonized and as much as possible of the vegetable matter and other dirt removed. The removal of the vegetable matter from the wool occurs at every possible point in the manufacture of the yarn, so that when the wool is ready to be spun it should contain none of the foreign substances that became attached to the fleece during the life of the sheep. Vegetable matter remaining in the wool, if spun into the yarn, causes a rough, uneven thread, thus greatly deteriorating the value of the yarn and of the resultant fabric.

Stock that has been mixed, either for color or quality, must be well blended before the carding is begun, for otherwise the cards will have to perform the work of the mixing picker as well as card the wool or mixture, and inferior work will result. The wool should be run through the mixing picker as ufficient number of times to open the stock thoroughly; the work of the cards will thus be greatly improved, because the stock will come to them in an open condition and with few matted lumps to be opened out. It should be well lubricated with oil or emulsion in order to preserve the natural structure of the fiber from injury during the carding process. If not well oiled before being put on the cards, the serrations of the fiber will be injured by the friction of the fibers with each other and with the card clothing. It will also produce a large percentage of flyings owing to its dry condition. If, however, the stock is lubricated, the serrations of the fibers become filled with the lubricant and slip past one another easily, thus becoming disentangled without difficulty and allowing the natural formation of the wool in locks, or staples, to be broken and an artificial arrangement of the fibers made that is necessary to the objects in view. No amount of oil will restore to its perfect natural condition stock tha has been made harsh in the scouring or drying, but the application of good oil in liberal quantities will aid its carding and spinning to a great extent.

It may be briefly stated, therefore, that before carding the wool should be well scoured, dried, and oiled so as to leave the fiber soft and pliable. It should also be well burr-picked in order to remove vegetable matter and burrs, which, if not removed, make the yarn uneven, and which, appearing in the resultant cloth make specks that may require the cloth to be either carbonized or speck-dyed.

2. **Objects of Woolen Carding.**—Carding has for its object the opening out of the fibers of the wool and their arrangement into an artificial form from which they can be spun into a uniform and even thread, and may therefore be said to be a continuation on a more systematic principle of

the opening-out process, which begins in the burr and mixing pickers. Although the wool in the burr picking and mixing was opened out, the fibers themselves were not separated from each other, but rather the wool as a whole opened out and rendered lofty. The carding not only opens out and disentangles the locks and bunches of wool, but actually separates the stock, fiber from fiber, and rearranges the individual fibers in a mixture of uniform density; it may, therefore, be said to be the first point where the wool is manufactured, or brought to an artificial condition.

It is obviously impossible to spin a thread from wool when it is in the condition of a large mass of stock, as in the previous operations; so when the stock is taken from the last carding operation, it is divided into **ribbons.** These ribbons are rubbed, by means of leather-covered rolls or aprons, into round threads of carded wool called **roving.** The roving is taken to the woolen mule and spun into yarn; in order that the yarn spun from it shall be even, the roving must be uniform in structure and absolutely free from particles of vegetable matter. The term roving is corrupted in some mills and districts into **roping;** as both terms are used more or less indiscriminately, each will be considered allowable.

Carding is sometimes looked on as the last process of opening out the wool, but it is also a good plan to consider it as the first operation in the manufacture of the yarn, since, when the stock leaves the finisher card, it is condensed into rovings, whereas hitherto the stock has existed only in a loose state. Rovings have no *twist*, but are simply continuous ribbons of carded wool, the fibers of which are rubbed together into a round thread, or strand.

By **twist** is meant a continuous spiral formation of a thread, which will be plainly seen by examining any ordinary thread. In the manufacture of woolen yarn a very small amount of twist is inserted at the side drawings of the first and second breaker cards by a rotating tube through which the sliver passes, and also to a much larger extent when it is spun into yarn on the mule.

The object of woolen carding is not so much to lay the fibers parallel as to mix and intermingle them on a uniform system so that the individual fibers will be thoroughly blended with one another. Thus, the object of woolen carding is different from that of either worsted or cotton, the carding of which tends toward parallelism. This is a fundamental feature of difference between the preparation of a woolen yarn from that of a worsted or cotton yarn. The fibers of carded wool point in every direction, while when on the fleece they had the same general direction; that is, the fibers being disposed in staples all pointed away from the back of the fleece.

3. The process of carding has been said to result in the breaking up of the natural and substituting an artificial arrangement of the fibers, but there are other ends to be attained and the various objects of woolen carding may be said to be: (1) To break up the natural formation of the wool, in which it clings together in small tufts, or locks; (2) to accomplish a thorough amalgamation of the individual component fibers and their rearrangement into a uniform artificial blend; (3) to clean the wool of refuse matter that has escaped the previous operations (this is generally in the form of dust and short straws, commonly called shives); (4) to accomplish a division of the carded stock into ribbons of equal weights and condense them into rovings suitable for spinning.

On the thoroughness of the carding depends the accomplishment of the results named, and the resultant yarn is usually good or bad according to the manner in which the carding is performed.

METHODS OF CARDING

4. Carding by Hand.—The former method of carding wool was by means of hand cards, which are small flat boards about 12 inches long and 5 inches wide, having a handle attached to one side. The face of the board is covered with leather, through which fine wires are placed, forming what is technically known as *card clothing*. The method of making card clothing has changed and it is now made automatically by machinery, but formerly the sheet of leather was pierced with holes by hand and the wire cut to the right length and bent in the form of a staple with a pair of pincers, after which it was thrust through the prepared sheet of leather. The wires, or teeth, of the card clothing were also bent forwards at an angle toward the handle of the card. Thus, if a lock of wool were drawn across the card against the points of the teeth it would engage with them, but would not catch if drawn in the opposite direction.

The method of carding wool by hand was as follows: A hand card was held in the left hand with the handle pointing away from the operator; the wool to be carded was spread on it and a similar hand card drawn lightly over the first card, which was held rigid. The bent teeth of the card clothing worked against each other and thus opened and combed out the wool. This constitutes the action of carding; i. e., combing the wool by means of card clothing working point against point, and is the same whether performed by hand cards or on modern carding machines. When the operator thought the wool was sufficiently carded, the handles of the cards were brought together and a peculiar shuffling motion commenced, the surfaces of the cards being drawn lightly across each other, which had the effect of bringing the wool from the cards in a roll or, as it was called, a **rovelling.** This was due to the teeth of the cards working point against back and is known as **stripping;** the action is

the same, namely, point against back of tooth, on the woolen card used today.

Hand carding is employed today for matching mixtures in the mill. A small amount of wool of the various colors in the mix in the right proportion is carded by hand and, after the colors are thoroughly blended, the handful of wool is felted by hand into a sample *swatch*.

5. Modern Methods.—From hand carding the science quickly advanced to the roll, or cylinder, cards, which are in use at the present day. The first cylinder carding machine in America is in existence at the present day. There is some doubt as to whether it was built in England or America, but it made its appearance in the American woolen industry in 1792. Even with its wooden frame and clumsy appearance, it embodies the principles used in modern card construction.

The system of carding for woolen yarn practiced in most American mills consists of performing the carding on three cards, called the *first breaker*, *second breaker*, and *finisher cards;* taken collectively they are termed a *set of cards*. The finisher card in some districts is known as a *condenser card*, because as the wool leaves this card it is condensed into rovings by a machine, called a *condenser*, or *rub*, attached to the end of the card. The size of American woolen mills is gauged by the number of sets of cards.

The cards that constitute a set are usually coupled together by various kinds of feeds and carrying devices so that, with the exception of the feeding at a creel at the second breaker, the stock has a continuous motion from the self-feed of the first breaker until the rovings are wound on a jack-spool on a winding stand at the end of the finisher card. Each card has one main cylinder and its corresponding complement of other rolls.

Carding for woolen yarn as performed in Europe differs from the usual American system. Carding for worsted yarn differs from carding for woolen yarn both in America and in Europe. In accordance with the method adopted in

this Course, one standard system will be taken into consideration; namely, that of the American system of carding for woolen yarn.

6. Principles of Carding.—The two vital principles involved in the carding process are: (1) The carding proper, which consists of opening and carding the wool by means of rotating cylinders that carry on their surfaces card clothing filled with wire teeth, carding action taking place when the teeth on the cylinders work point against point; (2) the stripping of the carded wool from the cylinder that has performed the carding, which occurs when the points of the card clothing on one cylinder work against the backs of the teeth on the other.

FIG. 1

It is important to consider the inclination of the teeth, or the direction in which they point. The teeth of card clothing are all bent forwards in one and the same direction, so that if a lock of wool is drawn across the clothing against the back of the teeth, it will not engage with the teeth; but, on the

other hand, if drawn the other way, the clothing will quickly catch the wool. This inclination of the card wire is also known as the **keen** of the tooth. It will be readily seen that the operations of carding and stripping are both dependent on the inclination of the wire teeth of the card clothing, because if the teeth were straight, that is, at right angles to the foundation of the clothing, there would be no such action but the clothing would act simply as a brush. The principles of the carding and stripping action of card clothing are common to the carding of all fibers and with all carding machines.

Fig. 1 shows how the workers and strippers of a woolen card work in conjunction with the main cylinder and illustrates the principle of the carding and stripping actions of a card. The main cylinder e of the card revolves rapidly in the direction of the arrow, while the worker f slowly rotates in the direction shown by its arrow; thus the teeth on the main cylinder pass the teeth on the worker point against point. It will be seen that the actual carding, therefore, takes place at the point g_1 between the main cylinder and the worker, the wire teeth of the clothing on the cylinder e carrying the wool, which projects from the teeth and is readily caught by the clothing on the worker. The stock is thus combed, or carded, open, and deposited on the teeth of the worker; and, as this roll revolves, it is brought around to the point g_2, where it encounters a small, fast-running roll g, called a *stripper*. The clothing on the stripper works with its points against the backs of the teeth on the worker f, thus lifting the wool from the worker. From this it will be seen that the action of the stripper and worker at the point g_2 is not one of carding, but of stripping.

As the stripper revolves, the wool is taken from it by the teeth of the main cylinder, which work with their points against the backs of the stripper teeth and have a velocity in excess of that of the stripper teeth. Thus, the action at the point g_3 is also that of stripping. The stock is then carried forwards by the main cylinder to the next complement of workers and strippers, which are placed over it.

It must be understood that not all of the wool on the main cylinder is taken by the first worker, but that some may pass to the second worker, each worker taking a portion of the wool on the main cylinder; then, again, if the wool is not carded properly by the first worker and projects from the card clothing of the cylinder, it may pass around the same worker twice or even more times before passing to the next worker. With the exception of the *fancy* and the *feed-rolls*, the functions of which will be explained later, every roll on the card has either a carding or a stripping action on the wool, all depending on the inclination and relative velocities of the card clothing, which if it works point against point always cards the wool, and if working point against back of tooth has a stripping action.

CARD CONSTRUCTION

7. Dealing with the American system of carding for the production of woolen yarns, a suitable equipment of cards and machines for feeding the same would be as follows: *Automatic weighing and feeding machine, first breaker card, balling machine and creel, second breaker card, intermediate feed, finisher card, condenser, winding frame.* These machines constitute one set of woolen cards, as generally considered; that is, a set of cards consists of the first and second breakers and the finisher card with their respective feeding and doffing arrangements, although in ordering cards the feeds are not included. Before giving any instruction on the numerous feeding and other devices connected with woolen carding, the cards themselves will be thoroughly discussed.

THE FIRST BREAKER CARD

8. The object of the **first breaker card** is to perform the first carding process in the manufacture of a woolen yarn; consequently, as the wool is not so open when fed to this card as when it comes to the others, the clothing of the first breaker is made of heavier wire and the *set* of the card

FIG. 2

is more open. By the **set,** or **setting,** of the cards, the proximity of the rolls of the cards to each other is meant, as will be explained later. The principle of the first breaker is that of opening the wool by means of rotating cylinders covered with card clothing and adjusted to one another so as to carry out the principles of carding.

CONSTRUCTION

9. It will readily be seen that as the carding operation is such a delicate process and involves the separation of the individual fibers and their rearrangement, the construction of the machine on which this operation is performed is a very important element in governing the quality of the work produced. Owing to the fine settings and adjustments on a card necessary to accomplish these results, the greatest possible accuracy in their construction is observed.

In the Davis & Furber card, Fig. 2, the working parts are primarily supported by two straight-top frames, or beds, s that are connected by cross-pieces passing from one side of the card to the other and varying in length according to the width of the card. The tops of the two bed pieces, or frames, are carefully planed and leveled in order to secure firm and true bearings for the arches. The two arches s_1 are supported by the bed frames, to which they are firmly bolted, and carry the workers f, strippers g, and fancy, which is enclosed in a bonnet h_1. They are built in the form of arcs of circles and have projecting brackets, or arms, s_2 for the purpose of supporting the fancy. In this type of construction the main-cylinder bearings are carried by the arches.

In the process of making the cards, the frames and arches are carefully planed in pairs, each pair being used in the same card; this insures the uniform size and shape of each side of the card. In Fig. 3, the outline of the frame of the card is shown, but the arch is omitted so that the workers and strippers, which are carried by the same, can be clearly shown and also the belting plan of the card.

The working parts of the first breaker are carried either by the arches or by the frame and consist of the following:

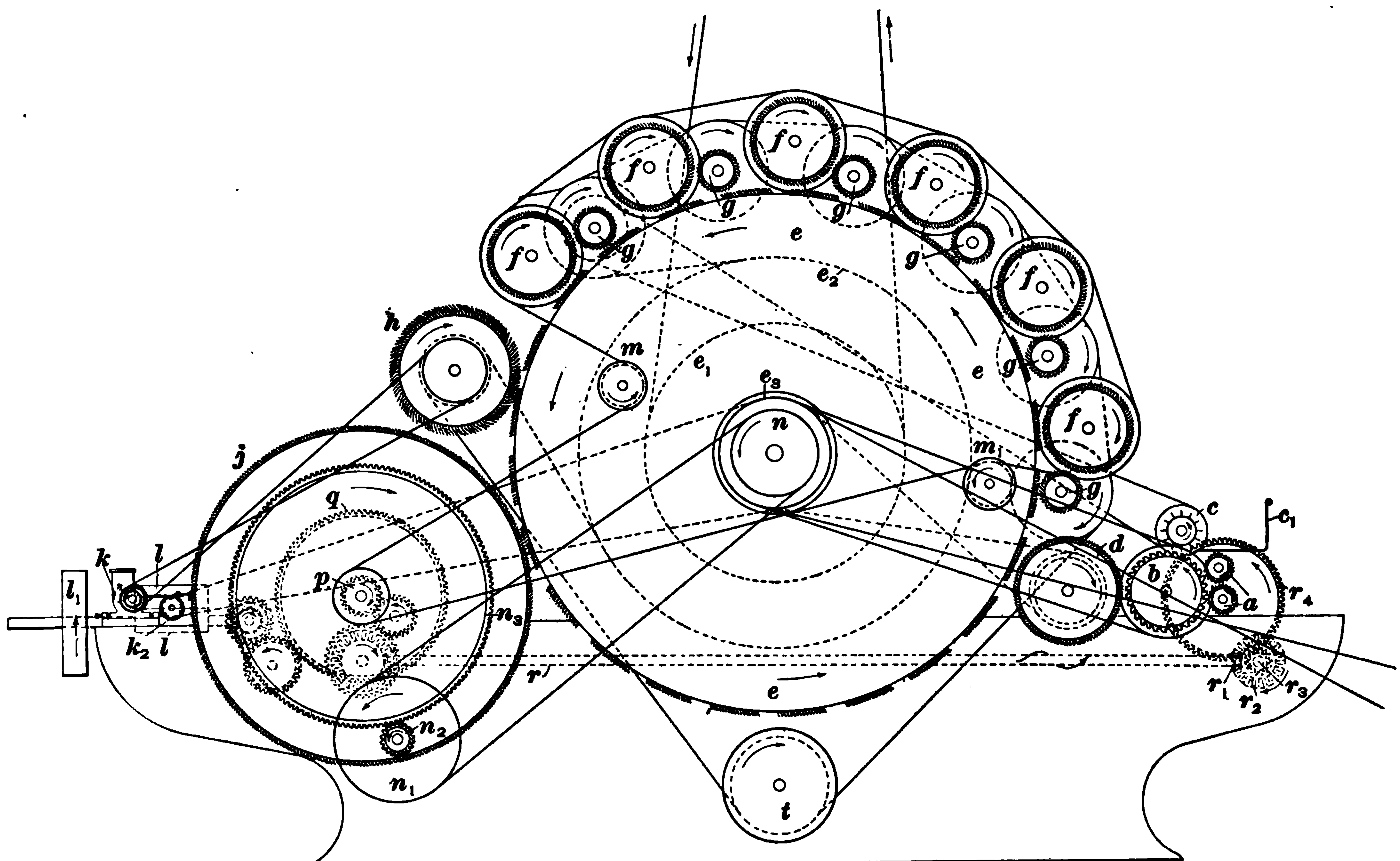


FIG. 8

Feed-rolls a, burr cylinder b, burr guard c, tumbler d, main cylinder e, six workers f, six strippers g, fancy h, doffer j, doffer-comb shaft k, doffer comb k_1 *(not lettered in Figs. 2 and 3), drawing-off rolls l, and pulley* l_1 *for driving balling machine.*

10. Feed-Rolls.—The rolls *a*, Fig. 3, that perform the function of feeding the wool to the card are 2 inches in diameter and are covered with metallic feed-roll wire. They are metallic and the wire used in winding is similar to that employed for the burr cylinders of burr pickers except that the form of the tooth is pointed instead of having a flat top.

11. Burr Cylinder.—This roll *b* is 7 inches in diameter and is covered with burr wire similar to that used for the burr cylinders in burr pickers. The **burr cylinder** is constructed entirely of metal and has the burr wire wound around it in a spiral, or helical, groove and firmly staked in.

12. Burr Guard.—Working in connection with the burr cylinder is a small roll *c*, known as the **burr guard**, that knocks any burrs remaining in the wool from the surface of the burr cylinder into a burr pan c_1 provided for such a purpose. The burr guard on the card is similar to the burr guards on the burr picker, with the exception of the number of blades, the one in the card being provided with twelve.

13. The **tumbler** *d* is a large roll 9 inches in diameter; its function is to take the wool from the burr cylinder and deliver it to the main cylinder of the card. It is usually made of wood with a steel shaft, but is made of iron when so desired. It is the first roll of the card that is covered with card clothing; the covering used here is known as *filleting.*

14. Card Clothing.—In order that the terms used in connection with card clothing may be understood (although this subject will be taken up later) the following explanation will not be out of place. There are two kinds of card clothing with which woolen cards are covered; namely, *sheet* and *fillet clothing.* **Sheet clothing** is prepared in sheets

5 inches wide and corresponding in length to the width of the card. This clothing is used only for covering the main cylinders of the first and second breaker and finisher cards, although most carders prefer filleting for the cylinder of the finisher. **Fillet clothing** is prepared in continuous lengths, or strips, of any desired width, usually from 1 to 2 inches. Rolls are covered with fillet clothing under tension so that the clothing will not become loose, the filleting being wound around the roll continuously, as a spiral, and securely fastened. Fillet clothing is applied to all rolls of a card that are covered with clothing with the exception of the main cylinders of the first and second breakers and the ring doffers, which are covered with special clothing.

15. The **main cylinder** is usually 48 inches in diameter and is one of the most important parts of a card, as on it falls the largest amount of work, since most of the other parts of the card are set to it. It not only acts in conjunction with each of the workers and the doffer in carding the wool, but acts as a conveyer, carrying the stock from the tumbler to the doffer. There are three methods of building main cylinders used for woolen cards; viz., wooden lag cylinders, wooden block cylinders, and iron cylinders.

Wooden lag cylinders are the ones usually attached to a woolen card unless some other construction is specified when ordering. This cylinder is built of carefully kiln-dried wooden lags on spiders attached to a central shaft, which in the Davis & Furber card is supported in brass-lined bearings enclosed in the arches. After the cylinders are put together they are turned down and carefully trued in order to insure accurate running.

Wooden block cylinders are, perhaps, the least used of all and are only furnished when especially ordered. The block cylinder is made by building the rim of the cylinder of blocks, or boards, set edgewise to the surface and carefully nailed or pegged and glued together. Block, as well as lag, cylinders are securely bolted to spiders attached to the main shaft of the card.

Iron main cylinders are coming into use more and more on woolen cards. An important advantage of the iron cylinder over the wooden is its immunity from the effects of atmospheric changes, which are apt to warp, either temporarily or permanently, a wooden cylinder so that its circumference will not run true.

The iron cylinder, if carefully trued in the machine shop, will run for years without any trouble, while the wooden cylinder may have to be trued or turned down every year, or even oftener, until it is thoroughly shrunk, owing to the uneven shrinkage of the wood. If an iron cylinder is once sprung out of true it is much more difficult to remedy the defect than is the case with a wooden cylinder and it usually necessitates the shipment of the cylinder to the machine shop where it was made; but when carefully made this ought seldom, if ever, to happen. In cotton carding, iron cylinders have entirely replaced wooden cylinders.

When a mill is shut down for some time the cylinders of the cards, if wooden, should be turned over by hand once or twice a week because, if allowed to stand in one position, there is liability of their warping out of true. It is well known that many types of textile machinery deteriorate more when standing idle than when in actual use.

The speed of the main cylinders of woolen cards is, for ordinary wool, from 90 to 100 revolutions per minute. There have been instances where the cylinders of woolen cards have been speeded up to 120 revolutions per minute, but the increased amount of flyings, or fibers of wool thrown from the card, in consequence of the velocity of its parts, and the liability of inferior work do not warrant this speed. For low stock, or with cylinders 60 inches in diameter, the speed should be slower; some carders on low stock run the cards at only 60 revolutions per minute.

16. The **workers** *f*, as their name implies, are the rolls of the card that, in conjunction with the cylinder, perform the larger part of the carding since the clothing on their surfaces works point against point with that on the surface

of the cylinder. On the card shown in Figs. 2 and 3, six 7-inch workers are placed over the main cylinder either in open brass-lined or in sleeve bearings, which are carried on stands having suitable means of adjustment, so that the setting of the workers to the main cylinder and to the strippers may be easily and accurately accomplished. Workers are usually made of wood, but may be made of iron if desired; the iron worker is less liable to get out of true, but if once sprung has to be returned to the machine shop to be remedied.

The number of workers placed over the main cylinder of a card varies according to the diameter of the cylinder, more workers naturally being placed over a 60-inch than over a 48-inch cylinder; however, the number of workers may vary even on cards with the same diameter of cylinders, eight workers being frequently used with 48-inch cylinders, although the standard equipment is six.

17. Strippers.—There are six 3-inch **strippers** *g* operating in conjunction with the workers on the first breaker card; owing to their small diameter, they are always made of iron. The strippers are placed in open brass-lined or sleeve bearings, which are fitted with a device for adjusting the proximity of the stripper to the main cylinder, but which admits of no lateral adjustment, as the setting of the worker to the stripper is performed by moving the worker to or from the stripper. The strippers and workers operate in pairs; there is always the same number of each on one card.

18. Fancy.—The function of the **fancy** *h* is unique. It has neither a carding nor a stripping action, but acts as a brush. The clothing has longer wires than the ordinary card clothing and they are set so as to dip slightly into the clothing on the main cylinder. The surface speed of the fancy is in excess of that of the main cylinder so that the clothing raises the wool to the points of the teeth on the cylinder, from which it is easily removed by the doffer *j*. The fancy is made of wood and is 10 inches in diameter, being enclosed in an iron bonnet h_1, Fig. 2, which

is made so as to be easily removed and is provided with a hinged cover. The fancy shaft is set in covered brass-lined bearings.

19. Doffer.—The first breaker card is provided with a 24- or 30-inch **doffer** j, made of wood or iron as preferred, which takes the wool from the main cylinder. The preferred size is 30 inches in diameter. Working in connection with the doffer is a doffer comb, which takes the stock from the same and from which it passes through a rotating tube to the drawing-off rolls. The oscillating doffer comb will be described later.

DRIVING

20. The feed-rolls of the card are driven from the doffer by a small gear p, Fig. 2, on the doffer shaft, which is the change gear for altering the weight, per yard, of the sliver or card end. This gear drives a train of gears, a pair of which are bevel gears, and turns a shaft r, known as the side shaft, running the length of the card. On the other end of the side shaft the bevel gear r_1 drives a larger bevel gear r_2 compounded with a small pinion gear r_3 that drives a large gear r_4 on the bottom feed-roll shaft. This drive is also shown in Fig. 3.

The two feed-rolls a are coupled together with gears on the opposite side of the machine, as seen in Fig. 2. The gear r_3 that drives the large gear r_4 on the bottom feed-roll shaft may be changed for an alteration in the weight of the side drawing, or sliver, from the card, as well as the gear p on the doffer shaft, which has been mentioned as the change gear. An increase in the number of teeth on either of these gears will result in a heavier sliver. The gear p on the doffer shaft is the one that is ordinarily changed for altering the weight of the sliver.

There is a device for throwing the small bevel gear on the feed-end of the side shaft of the card from contact with the bevel gear with which it meshes, thus allowing the feed-rolls to be stopped, which, consequently, stops the delivery

of wool to the card. This is accomplished by means of a small lever, or handle r_4, which is shown on the side shaft of the first breaker card, Fig. 2, and also in the illustration of the second breaker, Fig. 7; the device is the same in both cases. The feed-rolls of a card are always stopped and the card allowed to run out, or to clear itself as much as possible, before stripping or grinding.

21. In Fig. 2 it will be noticed that the card is equipped with the ordinary side-balling attachment, for the purpose of winding the side drawing, or sliver, from the card into balls that are placed in a creel and the slivers unwound and fed to the second breaker card. This arrangement consists of a drum o driven by bevel gears from a shaft located just beneath the doffer. The delivery rolls l are driven from a train of gears from the drum shaft and the sliver of wool as it is delivered passes through a reciprocating guide y_2 and is wound on a spindle supported by the arms o_1. The guide is fastened to a bar y_1 that receives a reciprocating motion by means of a crank-movement from the gear y. The rotary motion necessary for winding the sliver of wool into a ball on the spindle is obtained by means of the constantly rotating drum on which the ball of wool rests as it is formed.

This balling arrangement is not attached when a balling machine is used, but a pair of delivery rolls, as shown in Fig. 3, is substituted.

By referring to Fig. 3, which is an illustration of a left-hand card, the driving of the various parts may be determined. There is considerable difference of opinion as to what constitutes a right- or left-hand card, but the weight of opinion seems to be that a right-hand card is one in which the driving pulleys are at the right of a person standing at the doffer end of the card and facing the machine, while a left-hand card has the driving pulleys on the left of a person standing in the same position. In Fig. 3 the bed frame of the card on the driving, or left-hand, side only is shown, the other, or right-hand, bed frame and both arches being removed and the parts of the card left unsupported, in order that all

the parts may be clearly shown. All parts that are on the left-hand side of the card, that is, the same side as the main driving pulleys, are shown in dotted lines where other parts intervene, and all parts on the right-hand side in full lines.

Cards are often made right- and left-hand and the sets arranged with the driving pulleys of two sets together.

The power is supplied to the card by means of 24-inch tight and loose pulleys e_1 on the main-cylinder shaft, as shown in Fig. 2. The doffer is driven by the small gear n_2, Fig. 3, engaging with the large gear n_3 on the doffer shaft. Compounded with n_3 is the pulley n_1 which is driven by the pulley n on the main-cylinder shaft. On the right-hand side of the machine is a 5-inch pulley on the doffer shaft, which drives all the workers. The belt passes over six 9-inch pulleys on the worker shafts and also around two movable flange binder pulleys m, m_1. The strippers and the fancy are driven from a 36-inch flange e_2 on the main-cylinder shaft on the driving side of the card. A belt passes around this flange and over pulleys on the fancy and stripper shafts. It also passes around an arbor pulley t, which may be lowered or raised by means of a rack and pinion operated by a hand wheel, thus allowing the stripper belt to be tightened when necessary.

The burr cylinder is driven from the pulley e_3 on the main-cylinder shaft on the right-hand side of the card. On the opposite side of the machine the burr guard is driven from a pulley on the last stripper shaft by means of a cross-belt. The tumbler is driven from a pulley on the main-cylinder shaft by means of a cross-belt on the left-hand side of the machine. In Fig. 3, there is also shown a crossed belt running down to the right, from a pulley on the main-cylinder shaft, which is for the purpose of driving the self-feed.

The main features of the device for driving the oscillating doffer comb k_1 are shown in Fig. 4, while in Fig. 5, the working parts that are enclosed in an oil-tight casing are shown. The comb is driven from a two-step pulley on the fancy shaft, which in turn drives a two-step pulley on the crank-shaft k_2 of the comb-driving mechanism on the right-hand or

left-hand side of the card as desired, but usually on the opposite side from the main driven pulleys (this drive is shown in Fig. 3). The crank carries a square, split block k_3, Fig. 5, that works between the tines of a fork k_2 setscrewed

FIG. 4

to the comb shaft k. As the crank-shaft rotates, it gives an oscillating motion to the comb, the horizontal play of the crank being taken up by the block sliding in the fork. This block is kept from working out from between the tines of the fork at the sides by means of two circular plates k_4 on the crank-shaft, one of which is shown. These parts are enclosed in a casing and are run in oil, the casing being oil-tight. The casing of the comb shaft and the bearing on the other side of the card are carried on slides, which allow for setting the same to the doffer.

FIG. 5

When carding low stock with a short fiber, it is often advisable to speed up the doffer comb; but when carding long, coarse stock, the comb should be slowed down, which may be readily accomplished by means of the step pulleys by which it is driven. The stroke of the comb should be such that its center is at its closest proximity to the doffer, and this point should be about opposite the center of the doffer. For short wool it is sometimes advantageous to arrange the stroke of the

comb so that when it is at the limit of its downward movement it will occupy a position somewhat higher than is necessary for long wool. The doffer comb makes from 1,200 to 1,800 strokes per minute, depending on the stock and the speed of the doffer.

SIDE DRAWING

22. The side-balling device shown on the card in Fig. 2 is not used except in the older mills. The method of taking the end from the card when a balling machine is used is shown in Fig. 6. The doffer comb is attached to the comb shaft *k* and removes the carded wool from the doffer *j*,

k_1

l_1

Fig. 6

whence it passes through the rotating tube k_2, which is driven by a grooved pulley on the main-cylinder shaft by means of a round belt or cord k_3. The object of the tube is to put twist into the card end in order to give it sufficient strength to be wound on the wooden spools in the balling machine. From the tube, the card end is passed through a pair of fluted-iron delivery, or drawing-off, rolls *l*. The bottom roll is driven by a train of gears from the gear *q* on the doffer shaft, Fig. 3, and the top roll is loose and rests on the surface of the bottom roll. A pulley l_1 is fastened on the shaft of the bottom delivery roll and drives the balling machine.

Fig. 7

THE SECOND BREAKER CARD

23. The **second breaker,** or **intermediate, card** is so similar to the first breaker as to require only a brief description. It has a main cylinder and other rolls of the same dimensions as the first breaker with the exception of the burr cylinder, which is replaced in the second breaker card by a cylinder called a **licker-in** covered with card clothing instead of burr wire. The reason for replacing the metallic burr cylinder with a licker-in covered with card clothing is that the wool as it comes to the second breaker is supposed to be free from large burrs and is already opened out by the action of the first card; it therefore does not need so strong an action as is necessary on the first breaker. A small roll running in connection with the licker-in, called the **licker-in fancy,** keeps the licker-in clean by raising the stock on it so that it can be taken by the tumbler.

The main features of the second breaker card are shown in Fig. 7; it will be seen that it is practically the same machine as the first breaker, the chief difference being that the card clothing is finer and set closer. It will be noticed, however, that the drawing-off rolls on the second breaker are of a slightly different pattern from those on the first and are also geared together; but this is unimportant. The feed-rolls on the second breaker are clothed with a very coarse sharp-pointed wire, known as *diamond-point wire.* A small feed-roll stripper keeps the feed-rolls clean and clear of wool; this takes the wool from the top feed-roll, where it tends to accumulate, and passes it to the licker-in.

In Fig. 7, a are the feed-rolls; a_1, the feed-roll stripper; b, the licker-in; c, the licker-in fancy; d, the tumbler; e, the main cylinder; f, the workers; g, the strippers; h, the fancy; j, the doffer; l, the drawing-off rolls.

24. The method of driving the second breaker card is the same as is used with the first; therefore, if any change is made in the number of teeth in the gear p on the doffer shaft or the gear r_3, a corresponding change will be made in

Fig. 6

the size and weight of the card end from the second breaker. As both of these gears are drivers, an increase in the number of teeth of either will produce a heavier sliver.

The train of gears for driving the delivery rolls of the second breaker is also shown, these gears being the same as those in the first breaker for the same purpose. A grooved pulley n_1 drives the overhead carrying rolls, which carry the sliver from the second breaker to the intermediate feed on the finisher card.

FINISHER CARD

25. The **finisher card,** Fig. 8, has the same general features as the first and second breaker cards. It is usually, but not always, of the same width as the other two cards of the set, but the cylinder is of the same diameter, as are also the workers, strippers, and other rolls of the cards with one or two exceptions, notably the doffers, of which there are generally two. This card is equipped with a pair of $1\frac{3}{4}$-inch feed-rolls *a* (which are a trifle smaller than those in the first breaker, although this is unimportant), $1\frac{3}{4}$-inch feed-roll stripper a_1, $5\frac{1}{2}$-inch licker-in, 3-inch licker-in fancy *c*, 9-inch tumbler.

The main cylinder *e* is of the same dimensions as those of the first and second breakers and, although sometimes covered with sheet clothing, is preferably covered with filleting. Many carders order their cards this way or recover the cylinders themselves, because the carded wool is taken from the finisher cylinder in continuous ribbons, which are condensed into rovings, and it is obvious that an even, continuous ribbon is not so easily obtained if there is a break in the clothing every 5 inches around the main cylinder, as is the case on a cylinder covered with sheet clothing. There is also an increased amount of carding surface when the main cylinder is covered with filleting.

There are only five workers and five strippers on the finisher card, owing to the extra room taken up by the two doffers. The fancy is of the same construction as those on the other cards.

26. Ring Doffers.—The two 12-inch iron doffers on the finisher are covered with card clothing in rings, which is an entirely different way of covering a roll from either the sheet or fillet method. **Ring doffers** are not entirely covered with the card clothing, but are divided into spaces, which are alternately covered with strips, or individual rings, of clothing.

Fig. 9 shows the details of the top and bottom doffers j_1, j_2

J_2

FIG. 9

on the finisher card. When the two-doffer system was first introduced, the rings on the top and bottom doffers were of the same width, but it was found that the rovings from the top doffer were heavier than those from the bottom, owing to the top doffer making the first stripping from the main

cylinder. In order to remedy this defect the rings on the bottom doffer *j*, are made wider than those on the top doffer. This is shown in the illustration, where it will be noticed that the rings are alternated so as to cover the whole of the width of the main cylinder.

The rings marked *j*, are the **waste-end rings.** They take the wool from the edges of the cylinder, where it is always heavier and uneven. The waste ends are wound on small spools at each side of the winding stand, which, when full, are doffed and the waste pulled apart and placed back in the first breaker feed. Occasionally a **waste-end conveyer** is used to carry the end back to the first or second breakers. There are several devices for this purpose, one carrying the ends back by means of a narrow traveling belt running overhead through a tube and depositing them on the second breaker, while another blows the waste ends through a pipe by means of a fan.

The clothing, or rings, of the ring doffers should be carefully cared for in order that the wire may not be bent or otherwise injured. Even and uniform roving cannot be obtained without the doffer rings being in first-class condition. The width of the rings varies according to the width of the card, and the number of rings according to the number of ends, or rovings, taken from the card. The number of rings and the number of rovings, of course, coincide, as each roving is condensed from the ribbon of carded wool stripped from a single ring.

The usual number of rovings for a 48-inch card is 48 plus the 2 outside, or waste, ends that must result when the usual type of intermediate feed is used, owing to the doubling of the sliver from the second breaker as it is laid across the feed on the finisher card. On a 60-inch card there are usually 60 rovings plus the 2 waste ends, but when a card is running on fine work, doffers with a greater number of rings are frequently used, and sometimes 80 rovings are taken from a 60-inch card. Sometimes 72 ends are taken from a 48-inch card and wound on three jack-spools instead of two, the number generally used for a two-doffer card. If a card is

under 48 inches wide, say 44 inches, there are generally 48 ends plus 2 waste ends taken off, although sometimes 40 ends are taken from a 40-inch card.

It must be understood that the respective cards of a set are usually of the same dimensions; that is, if the first breaker is 48 inches wide, the second breaker and finisher cards are also of the same width. Finisher cards, however, are sometimes built from 4 to 8 inches narrower than the first and second breakers.

27. A finger rack *z* is shown in Fig. 8. This is for the purpose of separating the slivers of wool and distributing them evenly across the entire width of the card when the latter is fed by a creel. The finger rack is removed when the finisher card is fed by an intermediate feed.

A gear on the bottom doffer shaft will change the speed of the feed-rolls, but it must be remembered that this will not change the weight of the roving when the finisher is fed continuously from the second breaker, since the size of the roving depends on the amount of wool delivered to the finisher from the second breaker. Therefore, in order to change the weight of the roving when the second breaker and finisher are coupled together with a continuous intermediate feed, it will be necessary to change the gear on the second breaker card. However, if the finisher card is not fed by the second breaker, but is fed separately by a creel or otherwise, as is sometimes the case with the older type of machinery, the gear on the finisher will change the weight of the rovings.

28. It is customary to run the workers on the finisher card in the opposite direction to that in which they run on either of the other cards, so as to prevent flyings and at the same time to strip the workers more evenly than when stripped in the ordinary way. The flyings settle around the ends of the workers and strippers and get into the cards, making the outside rovings more or less uneven and also heavier than the others.

With the worker running in the ordinary direction, about four-fifths of its circumference is loaded with wool, which passes up and over the roll before it comes in contact with

the stripper, the tendency of the stripper being to pull the stock off in flakes and bunches. This does not happen with the worker reversed, as it is only loaded for about one-fifth of its circumference and the wool passes on the worker directly from the main cylinder to the stripper without going completely around the worker. The stock is also subjected to more carding action with the workers reversed, because more teeth are passing each other between the workers and the main cylinder. The reversing of the workers is accomplished by crossing the worker belt as it passes from the pulley on the doffer shaft.

In woolen carding, the finisher card should have the most particular care, as on the manner in which this card manipulates the stock depends the character of the roving and, no matter how perfect may be the carding on the first and second breakers, if it is not performed correctly on the finisher and the rolls are not set right on the finisher, perfect results cannot be attained.

29. Width of Cards.—Woolen cards are made in various widths, the width of the card being reckoned as the width of the card clothing from one side of the card to the other. The customary widths are 36, 40, 44, 48, 54, 60, and 72 inches. The 48-inch card is the standard width, but a great many 60-inch and a few 40-inch cards are used; the other widths are rarely made unless the machines are especially ordered. Sometimes the finisher card for 48-inch first and second breakers is made 44 inches in width.

The set of cards described is made in the following sizes:

Width of card clothing, in inches .	48	48	60	60
Diameter of cylinder, in inches . .	48	60	48	60

30. The power required for a single woolen card varies from 2 to 4 horsepower, depending largely on the width of the card. It is also dependent somewhat on the character of the stock that is being carded, the weight of the material passing through the cards, and the speed at which the machines are run. A set of cards requires approximately three times the power necessary for a single machine.

31. Weight of Cards.—The average weight of a woolen card is about 5,000 pounds; that is, for a card with an iron cylinder and workers. If a wooden cylinder and rolls are used, the weight of the card is slightly less. The first and second breaker cards weigh approximately the same, but the finisher usually weighs more. A fair average weight for the finisher is 6,000 pounds, the extra weight being due to the *condenser*. The weight of an entire set of woolen cards may be estimated at from 15,000 to 20,000 pounds, according to the width and other factors.

32. Floor Space and Arrangement.—The average length required for a set of cards, including the intermediate spaces between the cards, is 42 feet 6 inches. Of course this varies somewhat in different mills according to the arrangement of the cards, although they are usually arranged with 4 feet or more between the ends of the frames for ordinary cards. The usual arrangement of cards in a woolen mill is to have the card room about 50 feet in width, placing the cards of each set end to end and arranging the sets of cards across the room parallel to each other. The length of the card room varies according to the number of sets, each card taking up from 7 to $8\frac{1}{2}$ feet in width, depending on the width of the cylinder. Occasionally, however, where an old room must be adapted for a card room and it is too narrow to permit the cards to be placed end to end, they are placed side by side.

33. Capacity.—The amount of work turned off by a set of woolen cards is such a variable quantity, and so many factors enter into the result, that no definite capacity can be determined on. It may be said, however, that the greater the width of the cards and the coarser the roving being made, the greater is the production. A fair average production for a set of cards 48 inches in width may be estimated at from 300 to 350 pounds of roving per day for 4-run yarns, and from 150 to 200 pounds for 8-run yarns. In carding for coarser yarn, the production often runs up to 500 pounds per day, and even more in some cases.

34. Speed.—The speed of a woolen card depends on the condition of the work. It is not advisable to run a 48-inch cylinder faster than 90 revolutions per minute, nor a 60-inch cylinder faster than 75 revolutions per minute; for low stock, cards are frequently run as slow as 60 revolutions per minute. Low stock has a tendency to make a large amount of flyings and, consequently, the card must be run slowly. It is also necessary to run a 60-inch diameter cylinder more slowly than a 48-inch one, owing to the increased centrifugal force of the large diameter, which throws the stock and increases flyings and waste, and also owing to the increased surface velocity of a large cylinder.

The best way to judge the speed of woolen cards is to find the surface speed of the rolls rather than the revolutions per minute. For fine stock, the surface velocity of the main cylinder should be from 1,000 to 1,200 feet per minute; for low stock, the surface velocity should be less, depending on the quality of the stock (length of fiber, etc.); it is frequently as low as 700 feet per minute. Harsh, dry stock also requires a reduced speed.

To find the surface velocity of a rotating cylinder covered with card clothing:

Rule.—*Add $\frac{3}{4}$ inch (allowance for height of card clothing) to the diameter of the roll, expressed in inches; multiply the sum thus obtained by 3.1416 and by the revolutions per minute of the cylinder. This product divided by 12 inches gives the surface velocity of the cylinder, in feet, per minute.*

EXAMPLE.—A 48-inch main cylinder on a woolen card makes 90 revolutions per minute; what is its surface velocity?

SOLUTION.— $\frac{48\frac{3}{4} \text{ in.} \times 3.1416 \times 90}{12 \text{ in.}} = 1{,}148.6475$ ft. per min. Ans.

CONDENSERS

35. There are many accessory appliances connected with cards which, although necessary, may be considered separately, since in many instances they are not built by the same builders as the cards proper. While a **condenser,** sometimes called a **rub,** is usually sold with and connected

to the finisher card, it is sometimes furnished by other builders. It is a machine for taking the ribbons of carded wool from the ring doffers of the finisher card and condensing, or rubbing, them into threads, or rovings. The several methods of making the flat ribbon of wool into a roving are all based on a rubbing of the roving between leather surfaces.

ROLL CONDENSER

36. A section of what is known as the **roll condenser** is seen in Fig. 10, which shows one doffer of the finisher

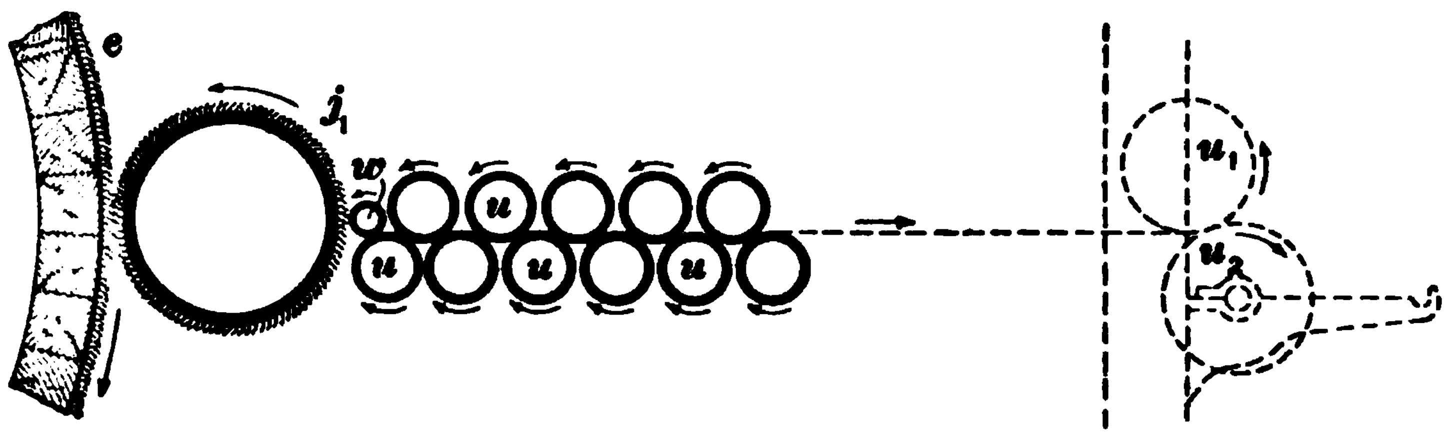


FIG. 10

with its corresponding **rub rolls.** In the ordinary card there are two doffers and two sets, or nests, of rub rolls, while on some cards there are three doffers and three sets of condensing rolls. In Fig. 10, the cylinder of the card is marked e; j_1 is the top doffer and w is a wipe roll that strips the wool from the doffer rings and passes the ribbons to the rub rolls u. The wipe roll is usually covered with corduroy, but is sometimes covered with wire for special purposes. It passes the stock to the rub rolls, of which there are sometimes 7, 9, 15, or (as shown in Fig. 10) 11 to each doffer. The rolls rotate in the direction shown by the arrows and also have a reciprocating, or traverse, motion imparted to them by means of eccentrics located at one side of the condenser. The rub rolls, being covered with leather and being a slight distance apart, rub the flat sliver taken from the doffer rings into a round thread, or roving. There is no twist put into the roving; the rolls simply rub the wool into a round form, the bottom rub rolls traversing to the right while the top rolls move to the left, and vice versa.

There is usually a draft of 1 tooth in a roll condenser; that is, the rolls farthest from the doffer are driven slightly faster. This draws out the threads, or rovings, to a slight extent and makes them smoother and more even. After being condensed, the rovings are wound on a jack-spool u_1 by surface contact with the rotating drum u_2 on the winding frame. A roll condenser gives excellent results on fine stock, but is not so well adapted to cheap material containing a large percentage of short, weak fibers.

APRON CONDENSER

37. The best condenser for all classes of work and the only one that can be successfully employed on very low stock is the **apron condenser,** which substitutes for the leather-covered rolls a series of leather aprons, usually two pairs of aprons to each doffer. The ribbons of wool passing between the aprons, which have forward and traversing motions imparted to them, are gently rubbed or rolled into a thread-like form.

A two-deck double-apron condenser is shown in Figs. 11 and 12; the former shows the gear end, while the latter shows the eccentric end of the machine. The condenser is designed to rest on the end of the finisher-card frame and consists of eight aprons v_1, v_2 suitably mounted and connected so as to have a reciprocating and also a forward motion. The aprons are honeycombed with fine indentations so that the rovings are more easily held and rubbed. A wipe roll, which is not shown in Figs. 11 or 12, is on the opposite side of the machine next to the ring doffers of the card, from which it takes the ribbons of wool.

Two belts are required for driving the condenser, one of which drives the gears imparting the forward motion to the rub aprons and wipe rolls, while the other drives the eccentrics on the opposite end of the machine, which imparts the traversing motion to the rub aprons. The power is supplied from the main-cylinder shaft of the finisher, a belt driving the large pulley v_3, from which the rub-apron shafts and wipe rolls are geared, as shown in Fig. 11.

The driving ends of the rub-apron shafts are made so that their section, or end, view is shaped like a cross. This

Fig. 11

allows the driving gears, which are made with holes to fit the shafts, to drive the apron rolls and at the same time

allows the shafts to be thrust through them so that the traversing motion may be imparted by the eccentrics located on the other side of the condenser, as shown in Fig. 12.

FIG. 12

The driving gears on the apron shafts are recessed in order to retain the oil and to keep the machine clean, it being necessary to have all parts of a condenser well oiled. The gears on the aprons nearest the doffers are 1 or 2 teeth

larger, as the case may be, than the gears on the last sets of aprons and are thus driven slower. This makes a slight draft between the two pairs of aprons on each deck, which is for the purpose of making the rovings evener and smoother. With low stock there should not be more than a 2-tooth draft between the aprons, for there is a liability of straining the rovings and making weak places, or **twits**. Fine stock will stand a draft of 3 teeth between the front and rear pairs of aprons, because the fine stock is more elastic, the fibers generally longer, and the spinning power of the wool better.

The adjustments for taking up the slack of the rub aprons, when they stretch, are placed on the rolls that do not carry the driving gears (only the front roll of each apron being driven and the apron running over a binder roll at the rear). They consist of screws v_4 with which the bearings of the apron roll can be forced back after they are loosened. As the screws for taking up the slack of the aprons move only the binding rolls, the aprons may be tightened without disturbing the driving gearing.

38. The wipe rolls have change gears that are made of the same diameter, but with a difference of 1 or 2 teeth, which is accomplished by changing the pitch of the gears. This allows the speed of the wipe rolls to be changed, as is sometimes necessary, in order to remove different kinds of stock from the ring doffers without disturbing their setting to the doffers. The two doffers of the finisher card are geared from the gear-end of the condenser, being driven from the front top apron shafts of each deck of rub aprons. The top doffer is driven from the top deck and the bottom doffer from the bottom deck.

39. Fig. 12 shows the eccentric end of the double-apron condenser and illustrates the method of imparting a traverse motion to the apron, by means of which the ribbons of wool are rubbed into rovings. The eccentrics v are fastened to a vertical shaft that is driven from the main-cylinder shaft of the finisher card through a pulley v_5 on a short shaft and a pair of bevel gears, which are protected by a guard. It will be noted that the eccentric shaft is driven from the opposite

end of the machine from the gear-end, but sometimes the driving shaft that carries the pulley driven from the finisher-cylinder shaft is continued under the rub aprons and the pulley placed on the other end, thus bringing both driving belts of the condenser on one side of the machine.

There are four eccentrics attached to the vertical eccentric shaft, which imparts the reciprocating motion to the top and bottom aprons of both decks, or nests. The bearings of the apron rolls on this side of the machine are carried on slides *v*, that are pivoted to the eccentrics, Fig. 12, by means of shell connectors on which the eccentric operates. The eccentrics may be readily adjusted to give more or less throw, according to whether more or less rubbing action is needed, by loosening two nuts on the under side of each eccentric.

The connection between the eccentrics and the slides may be lifted and the amount of eccentricity determined by means of an indicating pin; the farther the eccentric is out of center, the greater will be the traverse of the aprons and the more rubbing action there will be on the roving.

As this eccentric is really a shell eccentric and is made oil-tight, there is no leakage of oil. The setting of the aprons to each other was formerly accomplished by means of adjusting screws and was a difficult task, as the rub aprons should be set the same distance from each other on both sides of the machine. The setting on the condenser shown in Figs. 11 and 12 is accomplished by means of small slotted disks of sheet iron, which are made in two thicknesses, $\frac{1}{16}$ inch and $\frac{1}{8}$ inch; these are placed under the bearings of the apron rolls. If it is desired to give the roving a hard rubbing, the $\frac{1}{16}$-inch disks are inserted under the apron bearings; but if it is desired to have less rubbing action, the aprons are set farther apart by means of the $\frac{1}{8}$-inch disks.

Some classes of stock, especially low stock with harsh, short fibers, require more rubbing and the aprons must be set closer than with fine, lofty stock, in order to make the roving strong enough to hold together to be spun. More rubbing action may also be obtained by increasing the throw of the eccentrics.

40. In operation, the ribbons of carded wool are removed from the ring doffers by the corduroy wipe rolls; the slivers so removed are passed between the leather rub aprons, the forward motion of which passes the rovings forwards to the winding stand, where they are wound on a jack-spool, while the traverse motion of the aprons condenses the flat ribbons of carded wool into round threads, or rovings. It must be remembered that the wool is rubbed together and not twisted.

This apron condenser is usually sold with and applied to the finisher card previously described.

COMBINATION CONDENSER

41. Fig. 13 shows a section of a combination roll and rub-apron condenser. It will be noted that each deck consists of a wipe roll w, five rub rolls u, and a pair of rub

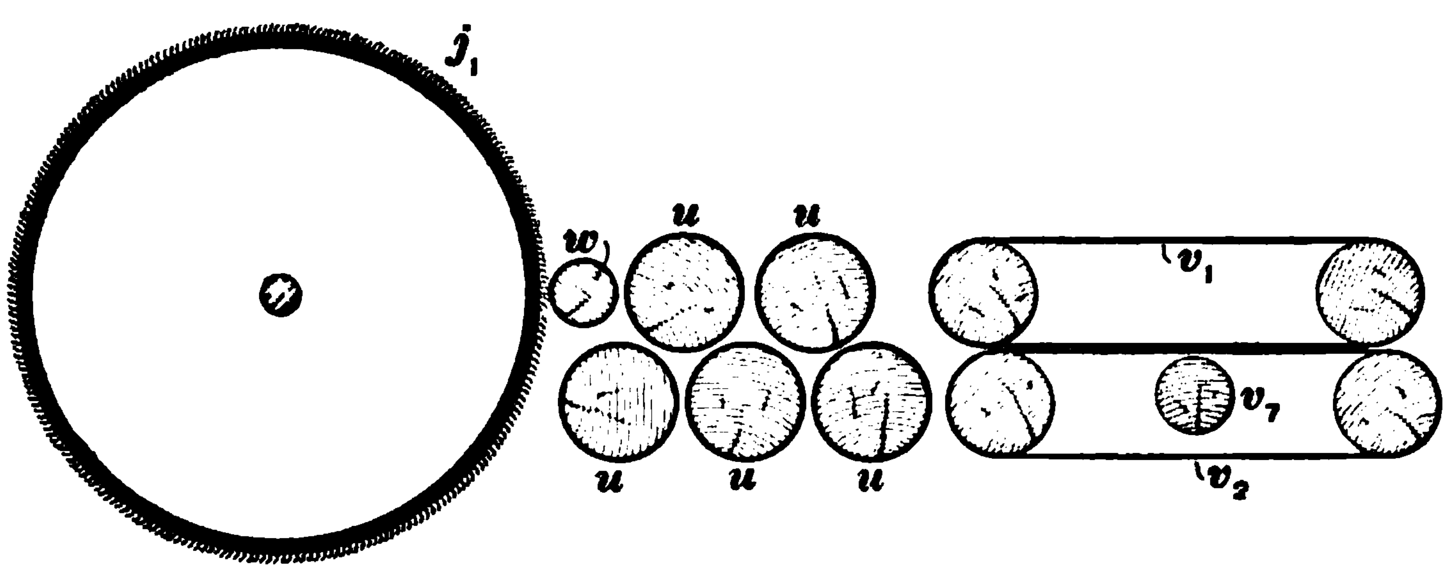


FIG. 13

aprons v_1, v_2. This type of condenser is built to combine the superior drafting action of the roll condenser with the excellent rubbing motion of the aprons. The roll v_7 is to keep the bottom rub apron from sagging away from the top apron. The finisher card shown in Fig. 8 is equipped with this type of condenser.

BOLLETTE CONDENSER

42. The **Bollette condenser** differs from other condensers in the fact that the finisher card is equipped with a single doffer that is entirely covered with fillet clothing, the stock being divided into ribbons by the condenser and not

by the doffer. The stock is removed from the doffer by a comb instead of a wipe roll and in a continuous web the width of the card. This web is then divided by steel knives, or *separators*, into ribbons of the required number and size, which are then rubbed into rovings by means of rub aprons in the ordinary manner. Bollette condensers are but little used in America, although they are used to some extent in England and to a greater extent on the continent of Europe.

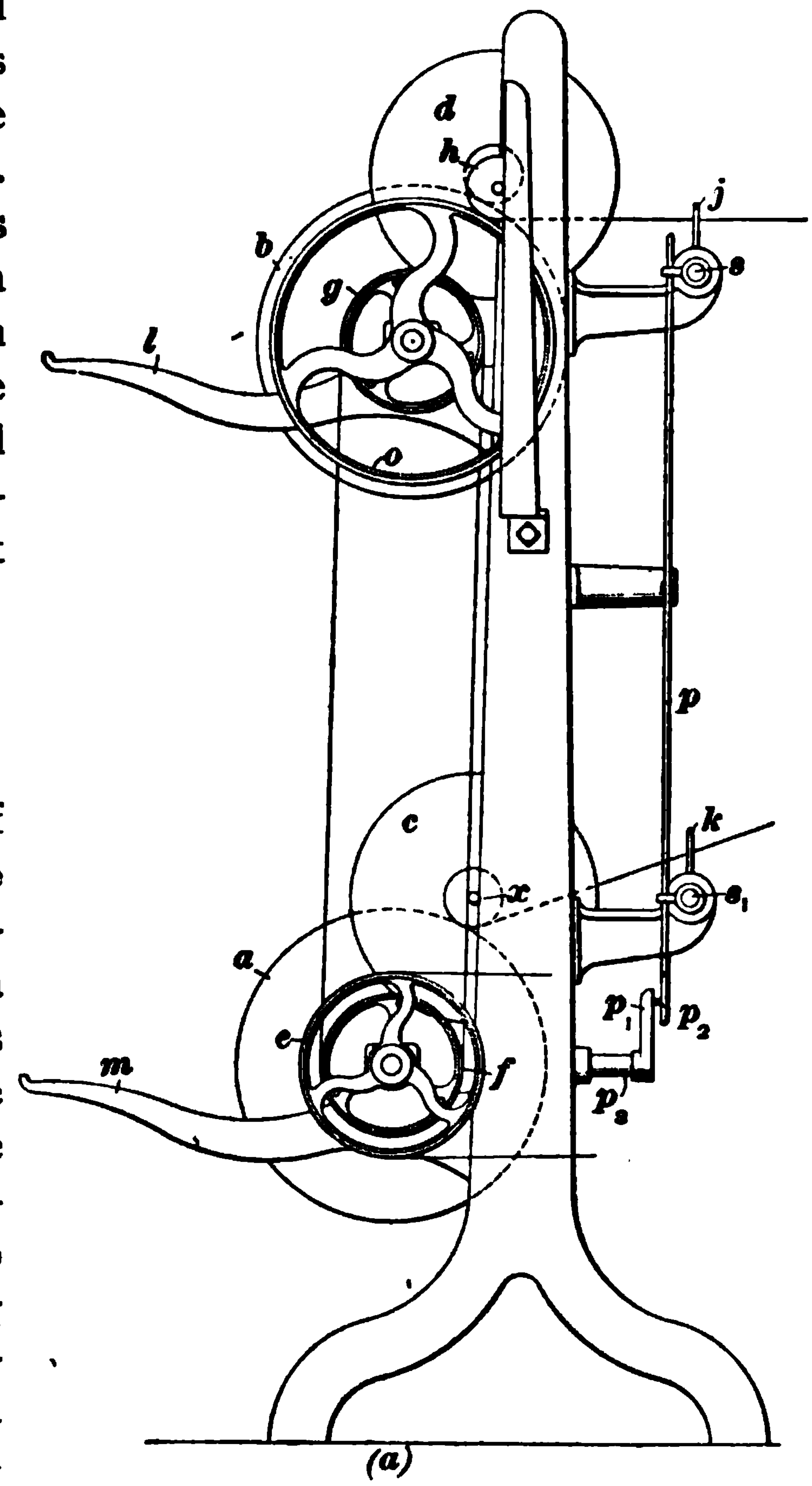


FIG. 14

WINDING FRAME

43. The object of the **winding frame** is to wind the condensed rovings on a jack-spool, which is then taken to the woolen mule, where the rovings are unwound and spun into yarn. The winding frame is usually driven from the condenser either by means of sprocket gears and a chain or by pulleys and a belt. The principle of the winding frame is simply that of surface contact with a revolving drum, on which the jack-spool rests and, being turned by the same, winds the rovings on itself as they are delivered from the condenser.

The winding frame or, as it is commonly called, the **spool stand**, is shown in Fig. 14 (*a*) and (*b*), the former being a side view and the latter a perspective view. It consists of two stands that carry the drums *a*, *b* on which the jack-spools *c*, *d* rest. The bottom drum is usually driven by a pulley on a stud driven from the condenser. This pulley drives the pulley *e* on the bottom drum shaft. A pulley *f* on the bottom drum shaft drives a pulley *g* on the top drum

FIG. 14

shaft. Attached to each end of the top drum shaft are two short drums, or pulleys, *o*, on which small spools *h* are placed to wind up the waste end made on each side of the card by the doublings of the intermediate feed.

The rovings pass through guides before being wound on the spools. These guides *j*, *k* are fastened to rods s, s_1 that have a reciprocating motion imparted to them by means of a lever p attached to a crankpin p_2 and a crank p_1, Fig. 14(*a*), which are driven from the bottom drum shaft by a pair of bevel gears p_4, as shown in Fig. 14 (*b*), and a short shaft p_3,

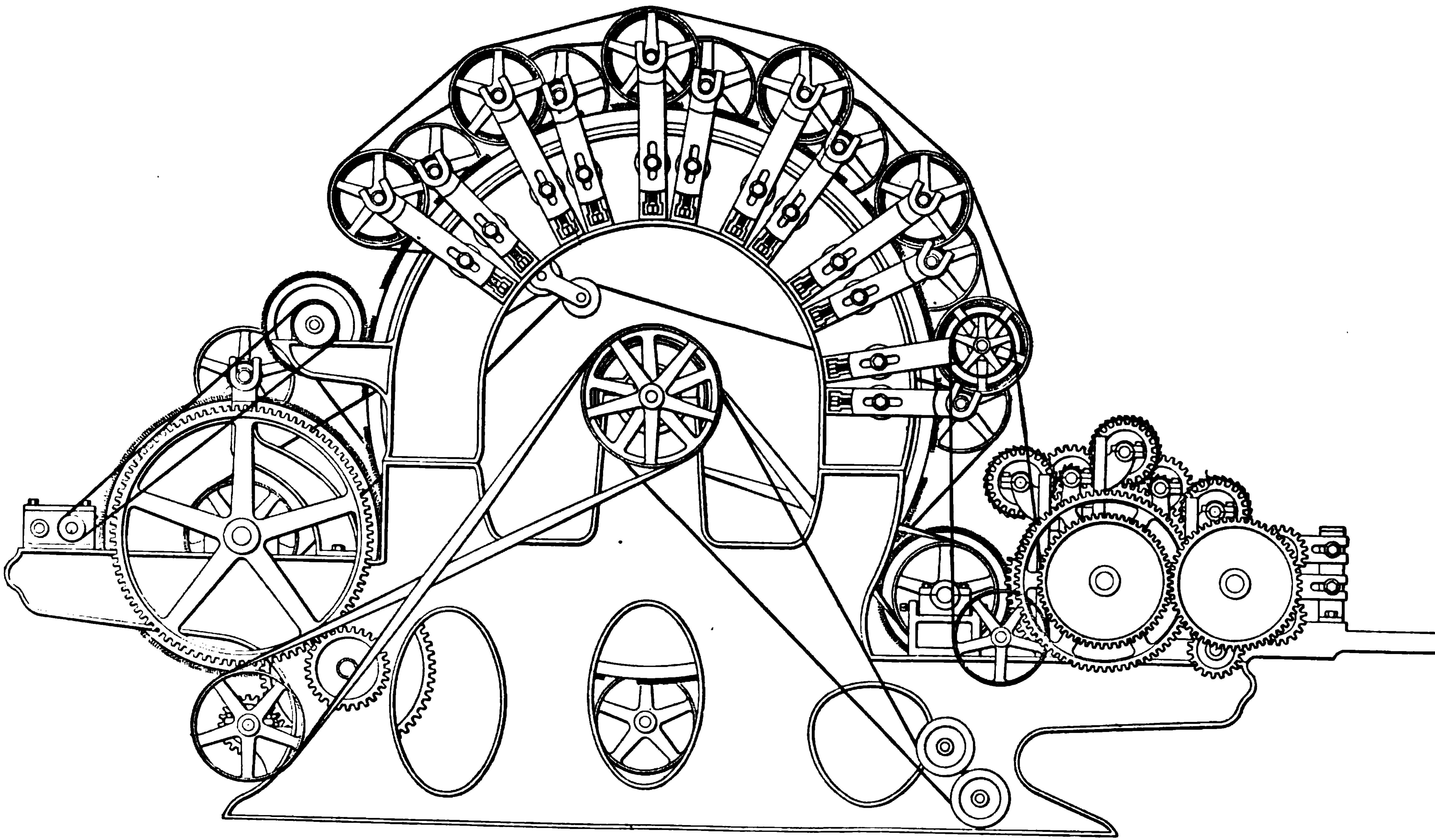


FIG. 15

Fig. 14 (*a*), on the other side of the frame. The reciprocating motion of the guides prevents the thread building up in one spot and winds the roving on the jack-spool without ridges. The two arms *l*, *m*, on each side of the spool stand, support the full spool while it is being doffed and an empty spool placed on the drum by the operator.

SMITH CARDS

44. The **Smith card** is shown in Fig. 15. The features in which this card differs from the Davis & Furber are mainly in gearing and belting the different parts of the machine, the principle of carding involved being the same. The frame of these cards also differs from the one described in that the bearing for the main cylinder is carried by the lower part of the frame, while the other is constructed with a straight-topped frame on which the arches rest. This may be seen by comparing Figs. 2 and 15. There are also minor details about the machine, such as the mechanism of the doffer comb and the method of setting the rolls, in which they differ.

FURBUSH CARDS

45. Another well-known make of cards is the **Furbush card,** which is made with practically the same style of frame as the Smith card and is built with 8-inch workers and 4-inch strippers—an increase of 1 inch in diameter in each case over the Davis & Furber workers and strippers. The Furbush finisher card, however, is built with five 7-inch workers and five $2\frac{13}{16}$-inch strippers. The main features of the Furbush card are seen in Fig. 16, which shows a first breaker with Bramwell feed. It will be noticed that this card resembles the Davis & Furber cards more than the Smith cards. The Furbush cards are made in widths of 24, 30, 36, 40, 48, and 60 inches, while as a general rule the main cylinders are 48 inches in diameter. The general size of all makes of cards have cylinders 48 inches in diameter

FIG. 16

and are 48 inches in width; that is, the width of the card clothing. There are some 60-inch cards in use, but owing to their width the workers, strippers, and other rolls are so long that they are much more easily sprung than the rolls on a card 48 inches wide. There is also a tendency for the long roll to sag in the center and thus be set closer in the middle of the roll than at its ends. Cards have been made 72 inches wide, but such a width is not often used. Occasionally cylinders 60 inches in diameter are met with; this size allows more workers to be used and gives a corresponding increase of carding surface. However, if the diameter of the cylinder is increased, the diameter of the doffer should also be increased; otherwise, the doffer will get out of condition much oftener.

WOOLEN CARDING

(PART 2)

CARD FEEDS

THE BRAMWELL AUTOMATIC WEIGHER AND FEEDER

INTRODUCTION

1. The question of feeding woolen cards is one of vital importance and should be accomplished in such a manner that the resultant yarn will have a definite size, or number. It is necessary that a constant weight be fed to the card and that the wool be uniformly spread, or delivered, in order that the best results may be obtained. Formerly, woolen cards were fed by hand, the operator being provided with a pair of scales in which to weigh the stock, and the feed-apron of the card being divided into uniform spaces by means of brass tacks or by painting certain slats black. A given amount of wool was weighed in the scales and spread over the area marked off on the feed-apron; the feeding was consequently often uneven and the carding poor. First breaker cards are now generally fed by a machine called an **automatic feed, or self-feed.**

The **Bramwell feed** is shown in perspective in Fig. 1, while elevations of each side are shown in Figs. 2 and 4. Fig. 3 shows the details of the device for controlling the motion of the elevating and stripping aprons of the machine. The principle on which the machine is constructed is that of

automatically weighing the stock fed to the card, the mechanism being so devised that equal weights of stock are spread uniformly on equal areas of the feed-apron and fed to the card

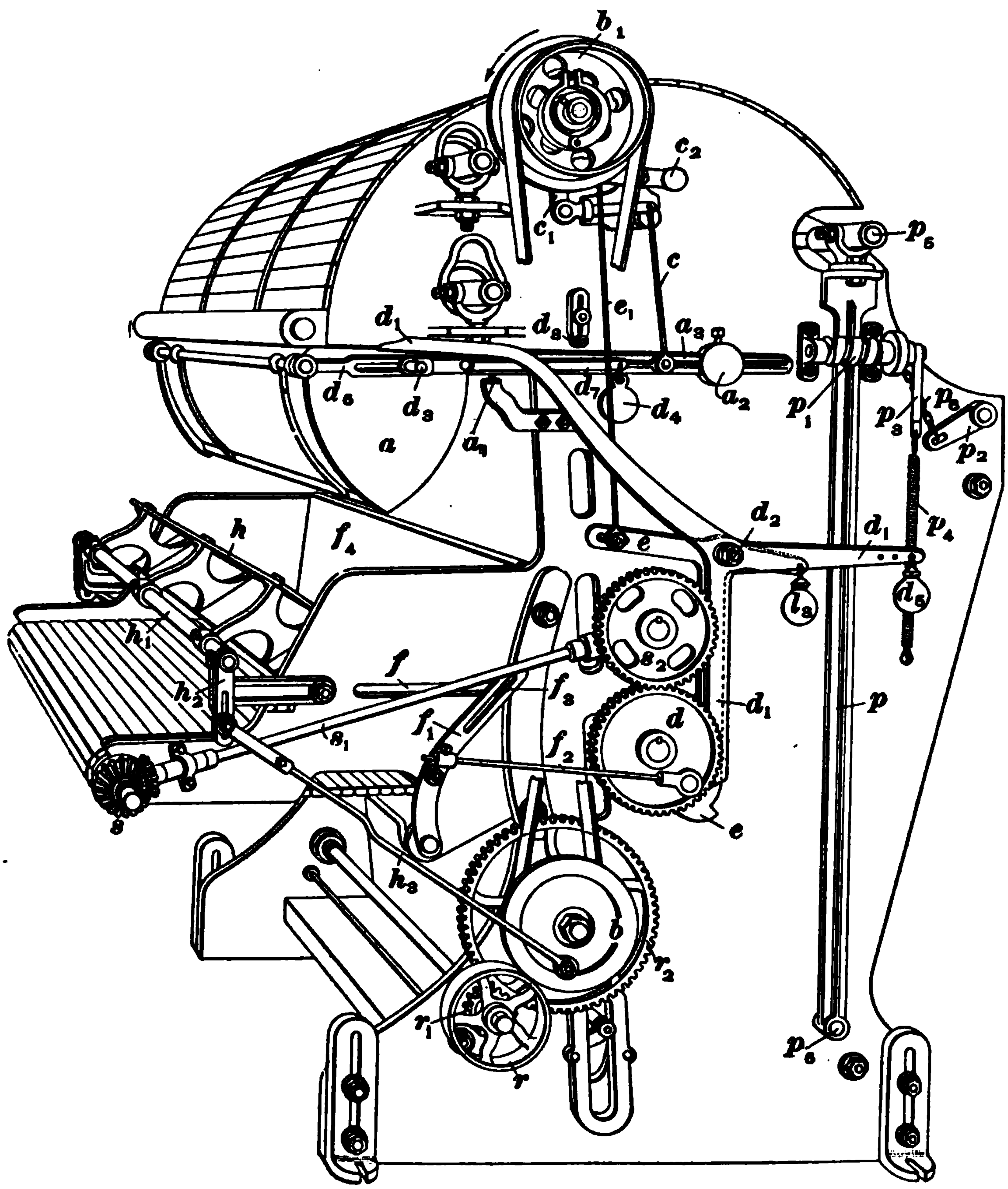


FIG. 1

during equal periods of time. This machine is used only for feeding first breaker cards and is built for cards of various widths, the standard sizes being 40, 48, 54, 60, and 72 inches.

CONSTRUCTION

2. Weighing and Dumping Mechanism.—The machine is constructed with a large hopper, or feed-box, in the rear of which is a spiked elevating, or lifting, apron for the purpose of lifting the stock from the hopper. As the stock approaches the top of the apron, it is brought under the action of an oscillating comb having a slow but long sweep, which combs off the surplus wool and leaves the rest evenly distributed on the apron. On the other side of the elevating apron is a short, fast-running, stripping apron provided with flexible strips of leather passing transversely across it. These sweep, or strip, the stock from the spiked apron and, acting in connection with a concave shell, or dish, deposit it in a weighing pan, or scale, a, Fig. 2 (a), which is suspended from the lever a_3 that is balanced on a knife-edge at a_1, and held in a raised position by the adjustable weight a_2. When a sufficient amount of stock has been deposited in the scale, the lever a_3 swings around its fulcrum at a_1, whereby the left end with the pan a will descend and the other end with weight a_2 rise until the lever strikes the stop d_2. By this motion it also raises a rod c attached to the elbow lever c_1, thus disengaging the pin c_8 from the notch in the end of the dog c_2, Figs. 2 (a) and 3 (b). When the dog c_2 is freed, its point rises, owing to the fact that the rear end of the dog is heavier, and engages with one of the teeth of the ratchet c_3, which by means of a clutch arrangement stops the delivery of wool to the scale a.

The construction and action of these parts are more fully shown in Fig. 3 in which (a) is a front view of the pulley b_1, (b) a view of the ratchet behind it, and (c) a side view of both in their true positions. As the pulley b_1 is not fast to the shaft b_4 it cannot drive the latter directly, but only by means of a sector c_4 that is keyed to the shaft. On the back of the sector and between the sector and the ratchet c_3 a small casting c_6 is fulcrumed. This piece has the shape of an elbow lever and is cast with a pin, or stud, c_6 on one end that projects through a curved slot c_7 in the sector. The

other end of the piece c_8 engages with a gap, or cut-out, in the edge of the ratchet c_3, which is loose on the shaft b_4.

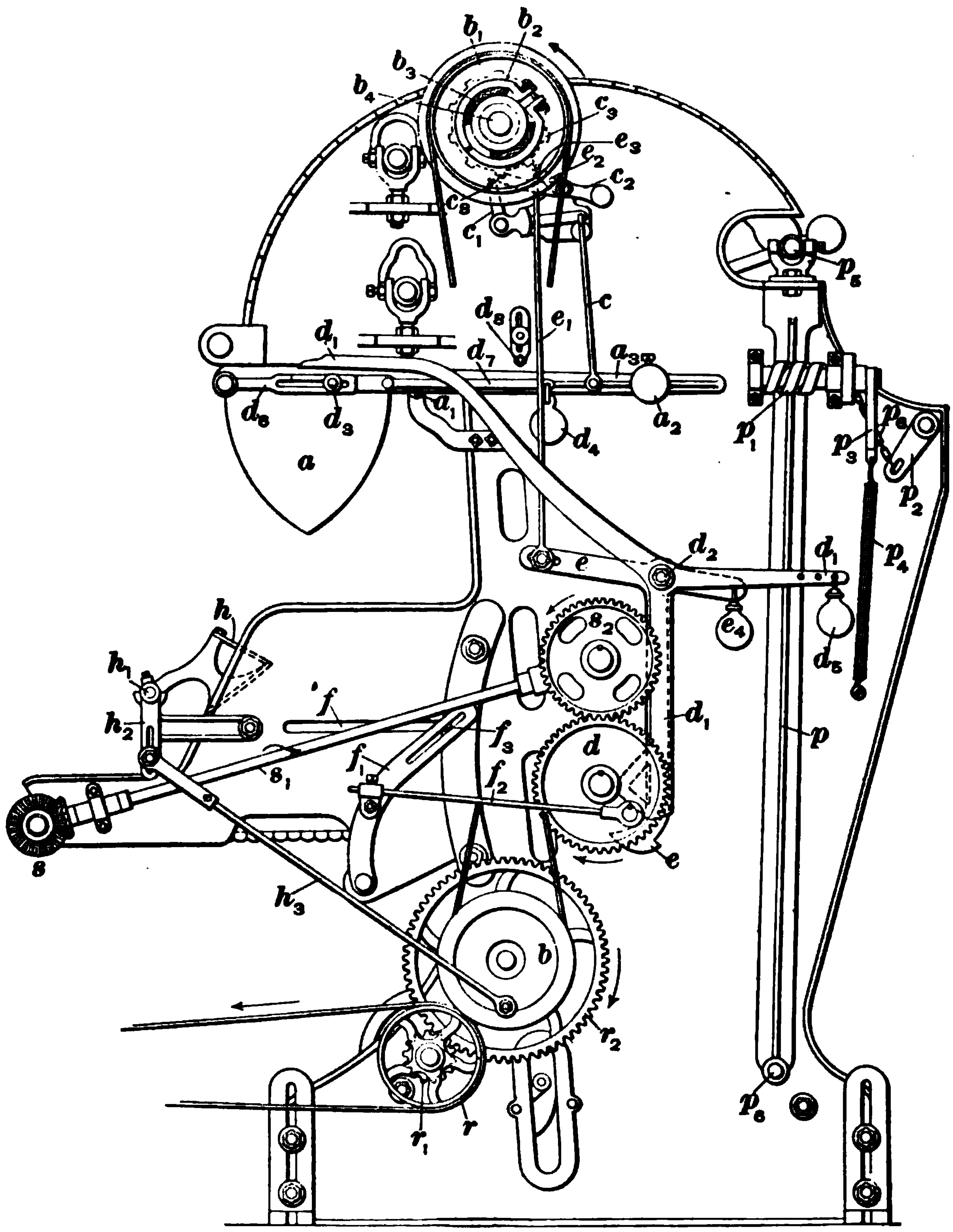


FIG. 2 (a)

The driving power of the pulley b_1 is transmitted to the sector c_9 and thereby to the shaft of the lifting apron by means of a stud b_2 on the pulley that engages with the

stud c_6 projecting through the slot c_7 in the sector. When these two studs are brought in contact, motion is imparted to the shaft; but if c_6 is moved out of the path of the stud b_2,

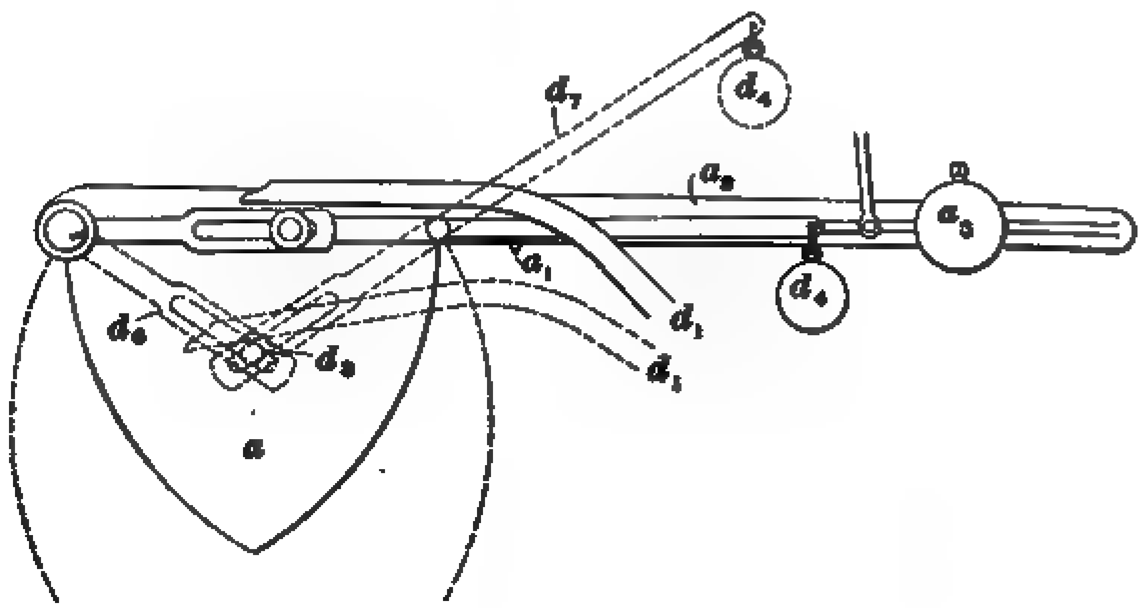


Fig. 2 (b)

as in Fig. 3 (b), the shaft will come to a standstill. When the dog c_3 is released and engages with a tooth of the ratchet c_2, the latter is stopped, but the sector c_1 will continue to revolve through a very small angle until the pin c_6 is withdrawn from the path of the pin b_2 on the pulley b_1. This is

(a)

(c)

Fig 3

accomplished by means of the gap in the rim of the ratchet with which the piece c_5 engages, because as the sector continues to revolve the elbow lever c_4 will be turned on its axis

since one end is held by engaging with the gap in the ratchet. This will have the effect of drawing the pin c_6 in the curved slot c_7 away from the pin b_8 so that no motion will be

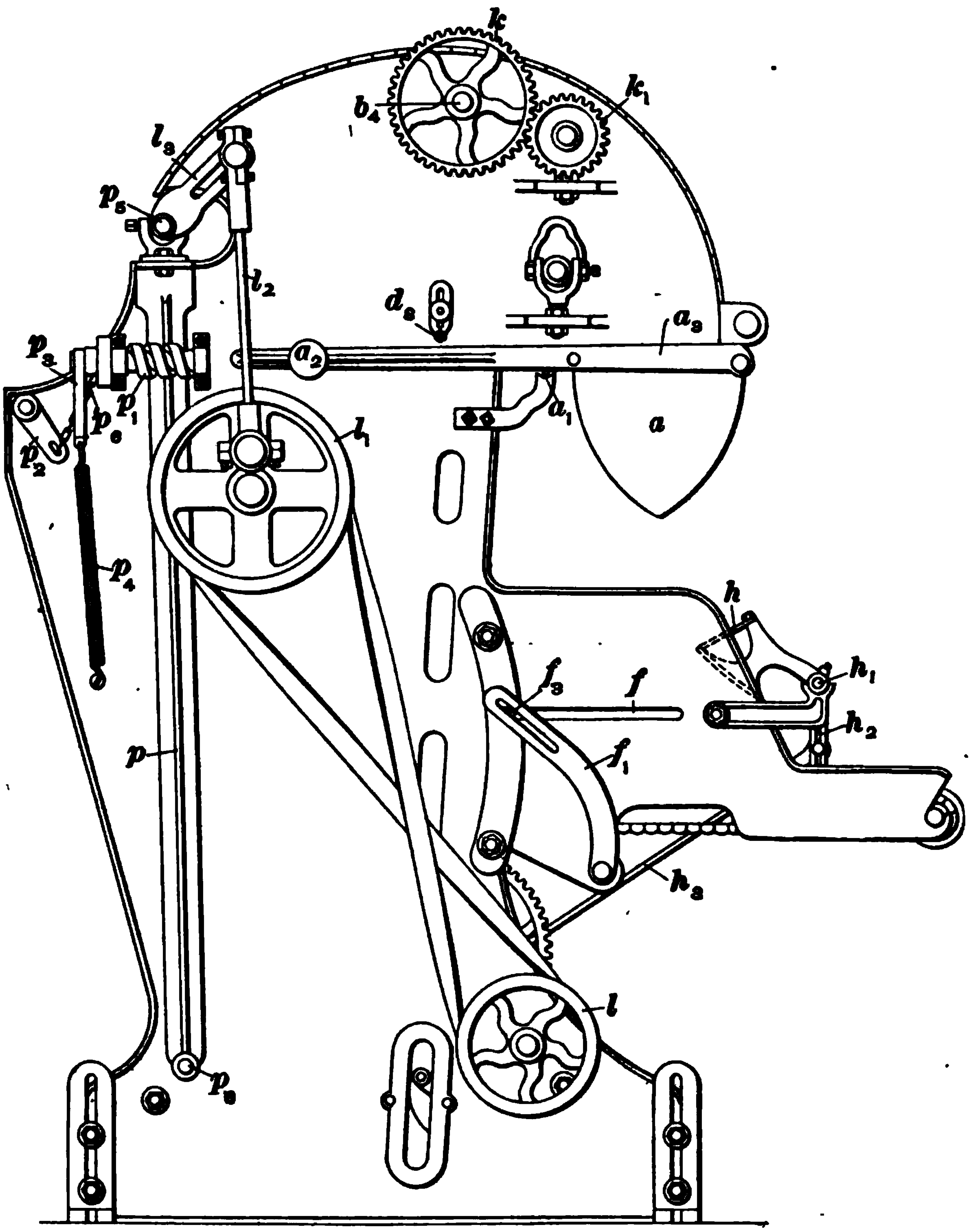


Fig. 4

imparted to the shaft; therefore, when the dog c_3 engages with the ratchet the lifting apron will be stopped. The pulley b_1 continues to revolve after the lifting apron is

stopped and the friction of the pieces of wood b_3 keeps the ratchet constantly pressed against the dog c_2 so that the latter will not be liable to move from contact with the teeth of the ratchet. The tension of the spring c_4 tends to move the pin c_6 back again into the path of the stud b_2; but as long as the pieces of wood b_3 in the friction arrangement on the pulley b_1 continue to revolve, the pin c_6 is prevented from receding into its original position. This can only take place when the dog c_2 is removed from contact with the ratchet; then the spring will contract and move the stud c_6 inwards and in front of the stud b_2 on the pulley, thereby causing the lifting apron to start again.

After the scale is filled and the lifting apron stopped, it remains at rest until a pin on the inside of the gear d Fig. 2 (a), comes in contact with the lever d_1, which is centered on a stud d_2. As the lower arm of this lever is operated on by the pin attached to the gear, its upper arm is lowered and presses down the pin d_3, which works in connection with arms d_6, d_7 attached to the wings of the scale. As the pin d_3 is pressed down, the wings of the scale are opened, as shown by the dotted lines in Fig. 2 (b), and the wool allowed to fall on the feed-apron. After the pin on the gear d passes from contact with the lever d_1 the lever is returned to its original position by the weight d_5, while the wings of the scale are brought together by means of the weight d_4.

The stock having been emptied from the scale, the lifting apron is started again by means of the same pin on the gear d that opened the wings of the scale. After this pin passes from contact with the lever d_1 it engages with the lever e, which is also pivoted at d_2. The lever e, operating through the rod e_1, pulls down a dog e_2, attached to which is a pin e_3 that projects over the dog c_2. Thus, when e_2, Fig. 3, is pulled down, the dog c_2 is disengaged from the ratchet c_3, allowing the pin c_6 to spring into the path of the pin b_2 in the pulley b_1 and the lifting apron to be started. When the dog c_2 is drawn down by the pin e_3, the pin c_6 on lever c_1 again engages with the notch at its end, preventing it from coming in contact with the ratchet c_3 until the scale is again

overbalanced. The lever e, Fig. 2 (a), is returned to its proper position, after the pin on the gear d is disengaged, by means of the weight e_4.

3. Stripping Apron.—Referring to Fig. 4, it will be seen that the **stripping apron** is driven from the lifting-apron roll shaft b_4 by means of the gears k, k_1. Thus, the stripping apron is stopped at the same time as the lifting apron; i. e., when the scale is overbalanced and the delivery of wool stopped. On the older machines the stripping apron was driven by means of a pulley and belt from the main shaft of the machine. This was a disadvantage, as wool was thrown into the scale after it had overbalanced and the lifting apron had been stopped, thus making uneven weighing. In case any pressure is applied to the scale before it becomes sufficiently filled with stock to overbalance, the lifting apron will be stopped exactly as though the scale were full, and in consequence a light dumping and correspondingly uneven place in the feed will result. To guard against interference of this kind on the part of careless persons, the words "Hands Off" are usually printed on each end of the scale.

4. Push Board.—After the stock has fallen on the feed-apron it is pushed forwards by a **push board,** so as to close up all inequalities, as the wool is liable to scatter somewhat when it drops from the scales. The device consists of a wooden board f_4, Fig. 1, extending across the feed-apron and carrying on each end a pin f_3. This pin extends through the slot f in the side of the machine and also through the slot in the lever f_1. The lever f_1 is given an oscillating motion by means of the connecting-rod f_2 that is connected to a crankpin on the gear d. The push board moves forwards, pushing the wool over the feed-apron to the previous weighing, closing up all irregularities, and then returns to its former position, at each revolution of the gear d.

5. Evener Motion.—There is also an **evener,** or **dabbing, motion** that strikes the wool lightly as it is spread on the feed-apron. This serves finally to even up the stock on the feed-apron before it passes forwards to the feed-rolls

of the first breaker card in an even sheet. This motion consists of a long dabber *h*, Fig. 1, which is connected by arms to a shaft h_1 extending across the feed-apron. The shaft and dabber are given an oscillating motion by a crankpin on the pulley *b* by means of the arm h_2 and connecting-rod h_3.

6. The **oscillating comb,** which evens up the wool extracted from the hopper, is driven by the pulley *l*, Fig. 4, on the main shaft of the machine that drives a pulley l_1 on a stud. A connecting-rod l_2 attached to the pulley l_1 by means of a crankpin gives an oscillating motion to the arm l_3, which is fastened to the comb shaft. The comb has a slow but long sweep.

The mechanism for regulating the proximity of the comb to the lifting apron is constructed as follows: The bearings of the comb shaft p_5 are carried on two vertical arms *p* that are pivoted at the points p_6 on each side of the machine. A small projection on the arm *p* works in the thread of the screw p_1, the position of which is controlled by an arm p_2 that is attached to the shaft of a wooden rack, or **comb regulator,** similar to the one used on the picker feed. This arm is attached by means of a chain p_6 to a boss on the shaft of the screw. A strap p_3 is attached to the screw and a spring p_4 is attached to this strap.

When the rack in the hopper is pressed down by the wool placed on it in the feed-box, the arm p_2 is also pressed down. This tightens the chain attached to the screw, causing the screw to be turned in such a direction that the arm *p* will be moved forwards and carry the comb nearer to the lifting apron, thus striking off a maximum amount of wool. As the amount of wool in the hopper is decreasing, the tension on the chain attached to p_2 is relieved, and the spring p_4 and strap p_3 turn the screw p_1 in the opposite direction, thus moving the arm *p* backwards and increasing the distance between the comb and the lifting apron. The amount of wool in the hopper is the element that regulates the distance of the comb from the lifting apron, thus rendering the amount of wool on the lifting apron evenly and uniformly distributed.

The comb blade is made flexible and may be set nearer the apron in the center than at the sides. This is usually advisable, as the friction of the sides of the hopper is apt to make the apron more lightly loaded at the sides than in the center.

DRIVING

7. The lifting and stripping aprons of the machine are driven from the main cylinder of the first breaker by a cross-belt, Fig. 2 (*a*), which drives the pulley *r* on the main shaft of the machine. This shaft should make about 150 revolutions per minute. A gear r_1 attached to the main shaft drives a gear r_2 compounded with the pulley *b*. From the pulley *b*, the various parts of the machine are driven as previously described, the pulley b_1 being driven from it with a crossed belt. The feed-apron, push board, dumping motion, and release motion for the dog c_2 are driven from a gear on the feed-rolls of the card that drives a gear on the front feed-apron roll shaft. A bevel gear *s* on the front apron roll shaft drives a gear s_2 on a stud through a side shaft s_1; the gear *d* is driven from the gear s_2, as shown.

The dumping arrangement being controlled from the feed-rolls of the card, which are in turn controlled by the gear on the doffer shaft, any change made at the doffer changes the speed of the feed-rolls of the card and of the dumping arrangement in proportion. The weight fed to the card may be changed in three places; viz., change gear on doffer, gear on feed-roll shaft, and weights a_2, which change the amount of the wool deposited in the pan.

TORRANCE BALLING MACHINE AND CREEL

8. The **Torrance balling machine** is a device for winding the side drawing from the first breaker card into flat balls, which are placed in a creel and fed to the second breaker card. One of the chief advantages of a balling machine is that the balls are made flat, or thin, which enables a large number of slivers to be fed to the second breaker,

With balls of wool formed by the first breaker card in the ordinary manner, fewer slivers can be fed to the second breaker, since the size of the balls requires a large and ungainly creel in order to allow the same number of ends to be manipulated. The more ends, or doublings, fed to the second breaker, the evener will be the rovings and the better

FIG. 5

the resulting yarn. Doublings are necessary in making an even and uniform thread and the more doublings used the more perfectly is the wool blended. Another advantage is apparent when small or sample lots of wool are being run through the cards. By means of the balling machine the balls can be made of any desired diameter; and if a small

lot of wool is being run through the cards, small balls of wool can be made and the same number of ends fed to the second breaker as with large lots of wool. The usual number of doublings for a five-bank creel with a 48-inch card at the second breaker is eighty, but this of course may be varied to suit any requirements.

The general features of the Torrance balling head and the method of attachment to the first breaker card are shown in Fig. 5; an end view is shown in Fig. 6 (*a*), while Fig. 6 (*b*) shows a side elevation of the balling machine.

Fig. 6 (*a*) shows the machine in its position immediately after the discharge of a full ball of wool and the reception of an empty spool e_1. The card end is wound on this spool by frictional contact with the large

Fig. 6 (*a*)

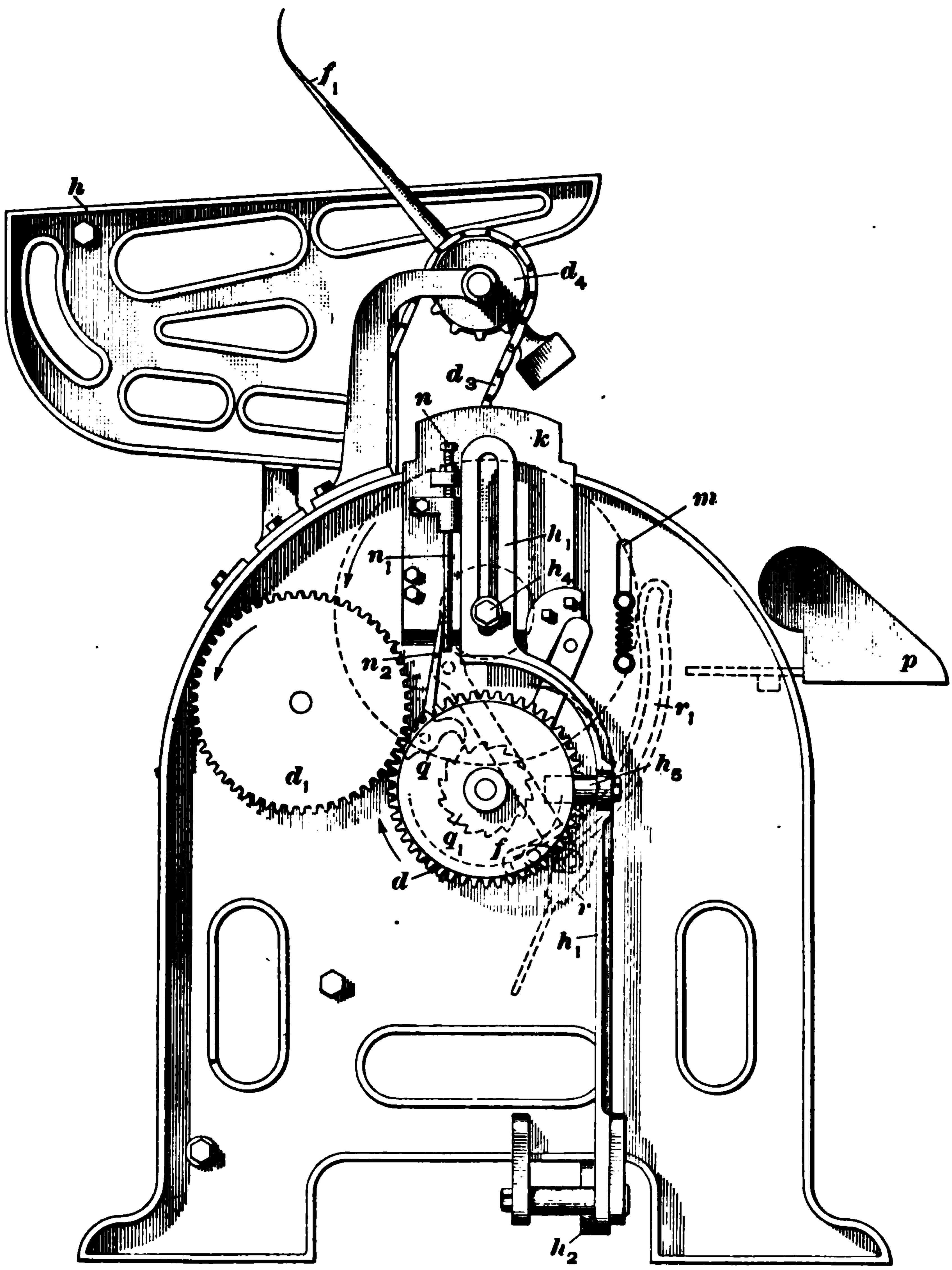


FIG. 6 (b)

fluted-iron roll b_1 on the central shaft of the machine, which derives its motion from the pulley a_1 through the gears x, x_1. The pulley a_1 is driven from a pulley on the bottom drawing-off-roll shaft of the first breaker card. Sometimes a large gear is used instead of the pulley a_1 and the machine geared from the first breaker card.

The operation of the machine is automatic; the empty spools are carried in a hopper, or magazine, h that holds twelve spools, which when filled are thrown out of the machine automatically into an iron box. This box is fitted with castors and is furnished with the balling machine and creel. The spool turns on a pin, or spindle, h_4 that is attached to the arm h_1. A corresponding arm h_2 on the other side of the machine is attached to a pusher slide. When a full ball of wool sets the doffing mechanism in motion, the arms h_1, h_2 are drawn back from each side of the machine. The arm h_1 withdraws the spindle from the spool, while the ball of wool is knocked into the box by the batten arm f_1; the arm h_2 meanwhile moves the pusher slide (which is not shown in the illustrations) and allows an empty spool to drop from the hopper h. The arms h_1, h_2 are moved out and then returned to their original positions by the cam f; in returning, the arm h_2 operating the pusher slide pushes the empty spool e_2 in place, as shown in Fig. 6 (a), while the arm h_1 thrusts the spindle through the hole in the center of the spool. An oscillating lever l_4, having at its top a ring through which the side drawing from the first breaker is passed, guides the sliver on the spool from side to side, while the two circular guide plates m insure that the sides of the ball are squarely built. The guide lever is driven by a gear l on the central shaft of the machine that drives an intermediate gear l_1. The gear l_1 drives a gear l_2 on the same sleeve as the disk cam l_3, which imparts the oscillating motion to the guide lever.

The batten arm that knocks the ball of wool from the machine into a receptacle on the floor is driven as follows: The gear d, set in motion when the full ball is ready to be discharged, drives the gear d_1. A sprocket d_2 attached to

the same shaft as the gear d_1 drives, through a chain d_3, a sprocket d_4, which is attached to the same sleeve as the batten arm f_1. The mechanism for discharging the full spool and replacing the empty one is necessarily intermittent and is controlled by means of the pin n_1, which is attached to the slide k. As the wool is wound on the spool, the slide k is raised by the increased diameter of the ball of wool and carries with it the pin n_1. When this pin slides by the finger n_2, a pawl q that is loose on a stud on the gear d engages with a ratchet q_1 on the main shaft of the machine and imparts motion to the cam f, and the gear d. By means of the cam f, the arm h_1 is drawn out; this draws the pin from the spool and at the same time the batten f_1 works around and knocks out the full spool, being driven from the gear d. The arm h_2 is operated by the arm h_1 by means of the pin h_3 and slot, shown in Fig. 6 (a), the motion being a reciprocating one.

9. The size of the ball is governed by the pin n_1; the lower this pin is, the larger will be the ball of wool, because of the longer time that elapses before the pin slips past the finger n_2. The pin may be raised or lowered by means of the threaded end n, which is provided with a check-nut that locks it in place, thus rendering all of the balls of wool of a uniform size. A breaker, or knife, r moves in a slot r_1 and laps the sliver of wool around the empty spool to start the new ball of wool after a full spool has been knocked out by the batten arm. The edge of this knife is provided with serrated teeth that part the sliver and release the full ball at the same time that the sliver from the card is wrapped around the empty spool.

The motions of the fluted-iron roll b_1, on which the ball of wool rests while forming, of the ratchet q_1, and of the oscillating lever l_4, that guides the sliver while it is being wound on the spool, are constant, but the other motions are intermittent and are controlled by the pin n_1, as previously explained. The guide plate p shown in Fig. 6 (b) is for the purpose of guiding the ball of wool as it is thrown from the machine and preventing its being thrown on the doffer comb of the card.

Fig 7

FIG 8

CREEL

10. The balls of wool that are prepared from the side drawing of the first breaker by the balling machine just described are placed in a **creel** at the rear of the second breaker card. The creel, shown in Fig. 7 in elevation and in Fig. 8 in perspective, consists of five sets of rolls on which the balls of wool are resting; it is known as a **five-bank creel.** The rolls are given a rotating motion and the balls *w* resting on them are thus unwound; the sliver of wool is delivered to the feed-rolls of the second breaker, being passed through a perforated steel guide plate *f*, the details of which are shown in Fig. 9.

The creel consists of two vertical stands that carry the bearings for the rotating rolls on which the balls rest; the rolls are driven, as shown in Figs. 7 and 8, from the feed-roll shaft *a* of the second breaker. Motion is imparted to an upright shaft *b* on one end of the creel by means of bevel gears. This upright shaft carries bevel gears *c* that impart motion to each set, or bank, of rolls on which the balls rest, by means of intermediates *d* and the gears marked *e* on the ends of the rolls. The balls of wool are separated from one another by means of iron rods passing from the top to the bottom of the creel between the rolls, as shown in Fig. 8. On each side of the creel, and opposite the three top banks, brackets *h* support iron rods *l* passing across the creel in front of the balls of wool; these prevent the balls of wool from being thrown out of the creel and falling into the card.

Fig. 9

APPERLY FEED

11. The **Apperly** is an intermediate feed that is usually attached to a finisher card but in some cases is used between the first and second breakers. Its object is to feed the stock continuously to the card and at the same time to secure a sufficient number of doublings of the stock to insure the evenness and uniform character of the rovings, this latter end being attained by laying the sliver from the second breaker so that it is fed diagonally on the feed of the finisher, thus allowing the ends of a number of slivers to pass into the card at once.

12. **Operation.**—The general features of an Apperly feed, feeding a finisher card continuously from the second breaker, are shown in Fig. 10, which also shows the overhead carrier rolls that support and transfer the second-breaker sliver. Fig. 11 shows a plan view of the feed, in which parts of the doublings have been omitted to show the aprons better, while Fig. 12 is a front elevation showing the mechanism for placing the sliver on the feed-apron. The wool as it is taken from the doffer by the comb of the second breaker is twisted by being passed through a rotating tube; this gives the sliver sufficient strength to be carried to the feed, which rests on the end of the finisher frame. The sliver, as shown in Fig. 12, is passed between two rolls m, supported by a carrier y that slides back and forth on a rod t extending diagonally across the machine. As the carrier y travels back and forth, the sliver is laid on a series of woven-cotton carrying aprons p that have a forward motion. Two latches r, Fig. 12, are lifted by the carrier each time that it reaches the side of the feed, and fall back in the loop formed by the sliver, thus holding it from drawing back as the next layer is placed on the aprons. The outside carrying aprons p_1 are called retention bands and are studded with short wires projecting through the apron only a sufficient distance to hold the sliver of wool from drawing back. In addition, as the successive layers of wool are carried

FIG. 10

forwards by the carrying aprons p, they are taken by spiked straps n, n_1, Fig. 11, which hold the slivers and do not allow them to contract after being released by the latches r. The spiked straps are filled with short wires about ½ inch in length and travel in the same direction as the carrying aprons and with the same velocity. The stock is carried forwards to a pair of feed-rolls x, x_1, Fig. 10, which deliver it to the licker-in of the card.

The stripping roll s keeps the stock from winding around the top feed-roll x_1 by stripping the wool from it and delivering it to the licker-in. The feed-rolls and stripping rolls are a part of the feed instead of being a part of the card, as in other instances.

13. Driving.—A large gear x_6, Fig. 11, driven from the side shaft of the finisher card is fastened on the bottom feed-roll shaft of the feed. On the same shaft a gear x_4 drives an intermediate gear x_5, which in turn imparts motion to a gear o_1 that is fast to the shaft of the front apron roll o. By this means motion is imparted to all the carrying aprons p and to the retention bands p_1. The spike straps n, n_1 are driven by grooved pulleys on a shaft z that receives motion from a gear on the shaft of the roll o that drives a gear z_1 on the shaft z. The top feed-roll x_1 is driven by a gear fastened to the shaft of the bottom feed-roll that drives the gear x_2 fast to the shaft of the top feed-roll. The gear x_2 also drives an intermediate x_3, which drives a gear s_1 on the shaft of the stripping roll. The driving of the carrying device for placing the sliver on the carrying aprons is as follows: A pulley a on the licker-in shaft of the finisher drives a pulley b by means of a crossed belt; attached to the same shaft as the pulley b is a gear c that drives a gear d on a shaft on the other end of which is a bevel gear e driving a bevel gear f. On the same shaft as the bevel gear f is a pulley g that drives a belt h, which also passes over a pulley g_1 at the other side of the feed. Attached to this belt is a projecting finger, or dog, k, also shown in Fig. 12, working in a slot of the carrier y, which slides easily on the rod t. The belt gives

FIG. 11

the carrier a reciprocating motion and the sliver of wool *l* is passed between the rolls *m* and laid on the feed apron as the carrier moves back and forth.

Although the number of doublings obtained is not so great, an Apperly feed is more desirable for a finisher than the creel feed in general use on the second breaker cards, since there is no danger of the ends running out and making imperfect spools of roving. The number of doublings obtained with an Apperly feed varies according to the width of the card, owing to the diagonal position of the slivers on the feed-apron. The average number of doublings is about 40, although with a smaller sliver and a 60-inch card as many as 60 ends may pass into the finisher at once. In using the Apperly feed, it is very important that the speed of the carrying aprons shall be so regulated that the sliver will be laid evenly and uniformly on them. If the aprons travel too slowly, the slivers will be crowded and will ride over each other, but if the speed is too fast, the feed to the finisher will be too light and rapid. In case the sliver is crowded, the fault may be remedied by placing a larger gear on the doffer shaft, which will drive the feed-rolls and aprons faster. A smaller gear on the doffer shaft will have the opposite effect and will make the slivers lie closer. It must be remembered that this change does not alter the amount of wool fed to the finisher or the size of the rovings, but simply makes the feed lighter and more rapid or slower and heavier, according to whether a larger or smaller gear is used; the same amount of stock is

fed to the card in a given time in either case. Sometimes the feed will not keep up to the second breaker but will allow the sliver to lie in coils on the floor. This is usually due to the slipping of the belt on the finisher and may be remedied by shortening the belt. Any great difference may be remedied by changing the speed of the carrier. A guide rod l_1, Fig. 10, is sometimes used to guide the sliver l; it is made in a curved shape so as to keep the tension on the sliver the same, whether the carrier is in the center of the feed or at either side.

BATES FEED

14. The **Bates feed** is very similar to the Apperly, the only difference being that the feed is positive and the sliver of wool is laid on the apron without any tension. In the Apperly, there is apt to be some tension on the sliver as it is laid on the carrying aprons, since the rolls m, Fig. 12, are simply driven by the friction of the sliver of wool, but in the Bates feed these rolls are given a positive motion by means of a rack extending across the feed.

SCOTCH FEED

15. Another feed that is sometimes used in this country but finds an extensive use on the continent of Europe is the **Scotch feed.** It operates on a principle somewhat similar to the Apperly, but does not twist the sliver into a rope. When using the Scotch feed, the sliver is taken off the doffer of the second breaker by an oscillating comb in the usual manner but, instead of being twisted by a rotating tube, it is simply passed through a pair of delivery rolls that press the side drawing into a flat ribbon from 3 to 5 inches wide, depending on the weight of the sliver. This ribbon of wool is carried overhead in the same manner as the sliver for the Apperly feed and is taken by a carrier that passes back and forth across the feed-apron of the finisher card, laying the

ribbons of wool on the same, each ribbon overlapping the previous one about one-half its width. The carrier passes back and forth parallel to the feed-rolls instead of diagonally, as with the Apperly feed; thus, the ribbon is only laid at an angle to the extent that the apron travels forwards while the carrier is making one traverse, the angle being first in one direction and then in the other.

The Scotch and Apperly feeds give excellent results with low stock and handle fine grades of wool in an equally satisfactory manner. With any feed of this description it is necessary to have two waste ends on the card, owing to the doubling of the sliver at each end, which naturally makes it heavier; thus, the two end rovings on the side of the card would be so heavy as to make the yarn spun from them a good deal heavier as well as uneven.

LAP FEED

16. Another method of feeding the product of one card to another is by means of **lap feeds,** which are rarely used in America although often met with in England and on the continent of Europe. The wool is taken from the second breaker in the form of a continuous roll, or lap, the width of the card; one or more of these laps are placed on the feed-apron of the finisher, where they are allowed to unwind and pass into the feed-rolls.

The disadvantages of a lap feed are the large amount of floor space required and the lack of continuity, the laps having to be doffed from one card and placed on the feed-apron of the other by hand. One advantage, however, of having all the cards of a set separate is that when stopping for grinding or stripping there is no loss of time by stopping the other cards.

OPERATION OF WOOLEN CARDS

17. The passage of stock through the set of cards and intermediate machines from the hopper of the Bramwell feed to the jack-spool is as follows: The wool is placed in the hopper of the self-feed, which deposits it in an even sheet on the feed-apron of the first breaker, from which it is taken by the feed-rolls and passed to the burr cylinder. This cylinder and the burr guard working in connection with it are identical in their action with the burr rolls and guards of the burr picker; the wool is drawn into the crevices of the metallic burr cylinder, and as the burrs remain on the surface they are knocked into the burr pan by the burr guard. The object of a metallic burr roll on the first breaker is also to open out the wool before it comes in contact with the card clothing, the first opening action naturally requiring a stronger and coarser-covered roll than the subsequent operations. From the burr cylinder the stock passes to the tumbler, from which it is stripped by the main cylinder, which carries it to the first worker where, meeting the points of the worker, which operate against the points of the cylinder, it is opened out and carded. The wool is taken from the teeth of the worker by the stripper, which operates point against back of the teeth on the worker; it is then taken by the main cylinder and again passed forwards so that other workers and strippers may operate on it, until it finally comes under the action of the fancy.

The function of the fancy is neither to card nor strip the wool but to raise it to the points of the teeth on the cylinder so that it can be readily taken by the doffer. To accomplish this the fancy wires are made long and flexible and are generally bent back from the direction in which the roll rotates. Sometimes, however, fancy wire is made straight; i. e., without any bend, or *knee*. It is usually set into the cylinder wire about $\frac{1}{32}$ inch; thus the fancy acts as a brush. The fancy is the only roll of a card that touches another, all other rolls being set a definite distance apart by means of gauges.

The wool having been raised to the points of the cylinder teeth by the fancy and the cylinder working against the points of the teeth on the doffer results in the wool being deposited on the latter. From this it is removed by the oscillating doffer comb and passes through the rotating tube to the drawing-off rolls, from which the sliver passes to the balling machine, where it is formed into flat balls. These balls are placed in the creel and the sliver unwound and passed to the feed-rolls of the second breaker.

The action of the second breaker on the stock is the same as that of the first breaker, with the exception that the burr cylinder is replaced by a licker-in covered with card clothing. There is also a feed-roll stripper for keeping the top feed-roll clean and a licker-in fancy for keeping the licker-in clear.

The wool is taken from the doffer of the second breaker in the usual manner and passed overhead to the Apperly feed, by which it is fed diagonally to the finisher card. The carding action of the finisher is similar to that of the second breaker, but the direction of rotation of the workers is reversed; this prevents a large amount of flyings and also produces evener rovings. The wool is raised on the cylinder by a fancy and is then divided into narrow ribbons by the ring doffers. These ribbons are taken from the ring doffers by the corduroy-covered wipe rolls and passed to the rub rolls, or aprons, which condense them into round rovings, or roping. These rovings pass through reciprocating guides on the winding frame and are then wound on a rotating jack-spool, ready to be spun on a mule.

METALLIC BURRING MACHINES FOR FIRST BREAKER CARDS

18. Instead of having only a single burring machine, consisting of a burr cylinder and guard on the first breaker, for removing the burrs before the stock passes to the card clothing, some cards are equipped with double burring machines or even a metallic breast. The object of such devices is not only to remove the foreign matter in dirty

stock but also to open out any snarls or bunches and not allow them to pass forwards to strain the card clothing. On certain classes of stock, burring machines are a benefit, especially for very fine wools, which tend to cling together in small lumps and bunches. Devices of this kind are never

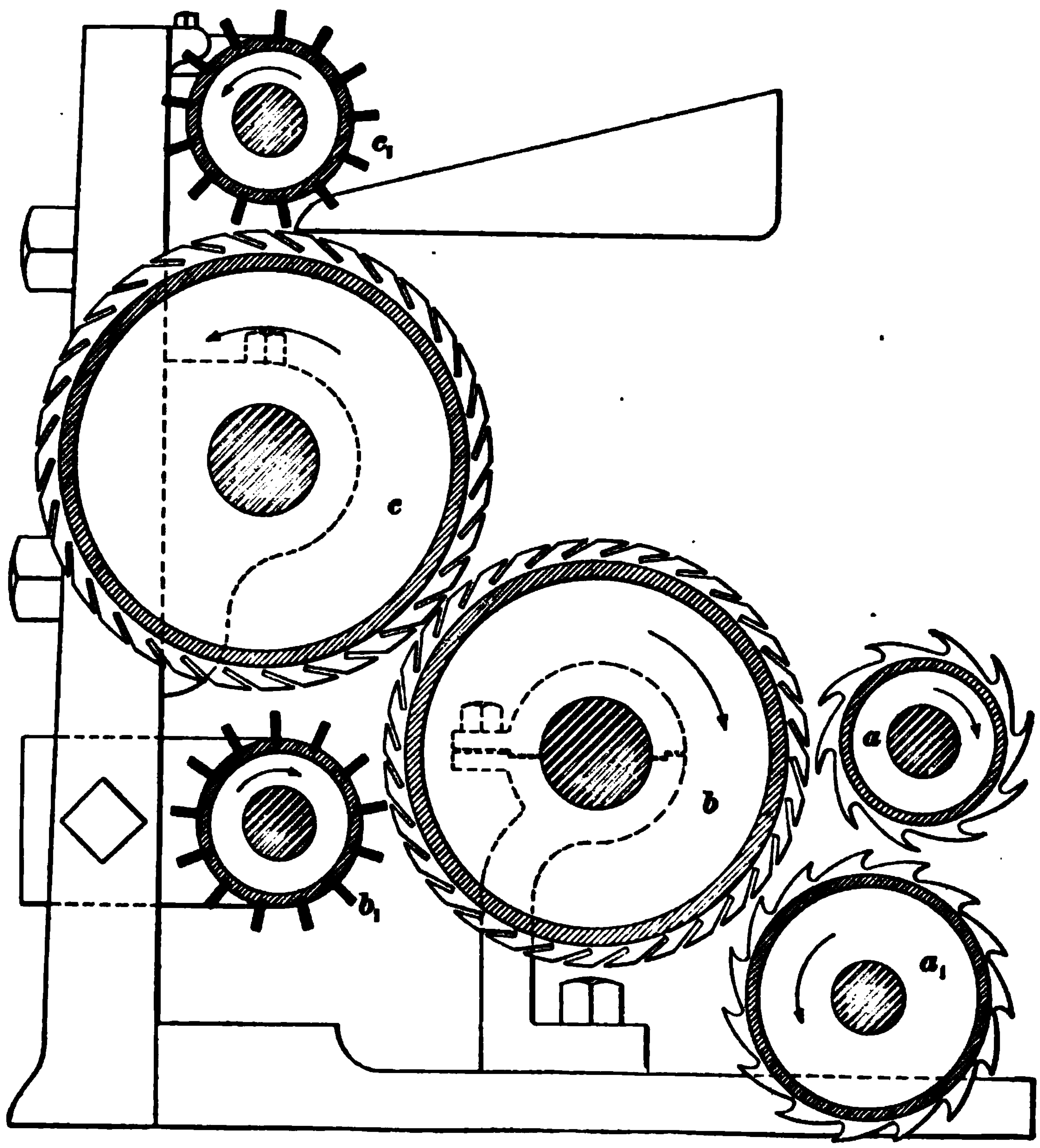


FIG. 13

attached to the second breaker nor to the finisher cards, as after the stock has passed through one carding process there is no necessity for metallic rolls.

19. **The Parkhurst double burring machine,** shown in section in Fig. 13, is often applied to first breaker cards. It consists of a pair of steel-ring cock-spur feed-rolls a, a_1,

two steel-ring burr cylinders b, c, and two burr guards b_1, c_1 with thirteen blades each; these parts are supported by a frame carrying the necessary bearings, which is readily bolted to the end of the first breaker frame.

In operation, the wool is taken by the feed-rolls and passed to the first burr cylinder, which, in connection with the burr guard b_1, frees it from burrs and dirt that have not been removed in the previous operations. The stock then passes to the second burr cylinder c, which, running up, receives on its surface the side of the wool already cleaned, completely turning over the lock of wool and presenting to the guard c_1 all burrs, etc. that are on the side not cleaned. The stock passes from the burr cylinder c to the tumbler of the first breaker card. The burr guard c_1 throws the burrs into a burr pan placed over the burr cylinders and the guard b_1 throws burrs and other refuse on the floor under the card. The top feed-roll a is stripped and kept clear by the burr cylinder b, which, running down, combs the wool through the teeth of the lower feed-roll a_1 and removes a large amount of shives, which are dropped under the card. A wipe roll is sometimes necessary for keeping the bottom feed-roll clear.

20. Smith Double Burring Machine.—Fig. 14 shows a form of double burring machine that contains burr cylinders of slightly different diameters. In the operation of this machine the stock is taken by a pair of feed-rolls a, a_1 and delivered to the first burr cylinder b, which strips the lower feed-roll a, while the top roll a_1 is kept clear by a stripper a_2. The burr cylinders are similar to those in the previous machine, the burrs being removed by two guards b_1, c_1 that knock them into the pans b_2, c_2. The tumbler t takes the wool from both burr cylinders and passes it to the main cylinder of the card.

21. Metallic Breast.—Occasionally, when very fine work is run, a **metallic breast** is used in connection with the first breaker. This operates on the same principle as the card, but owing to its slower speed is more gentle in its action and

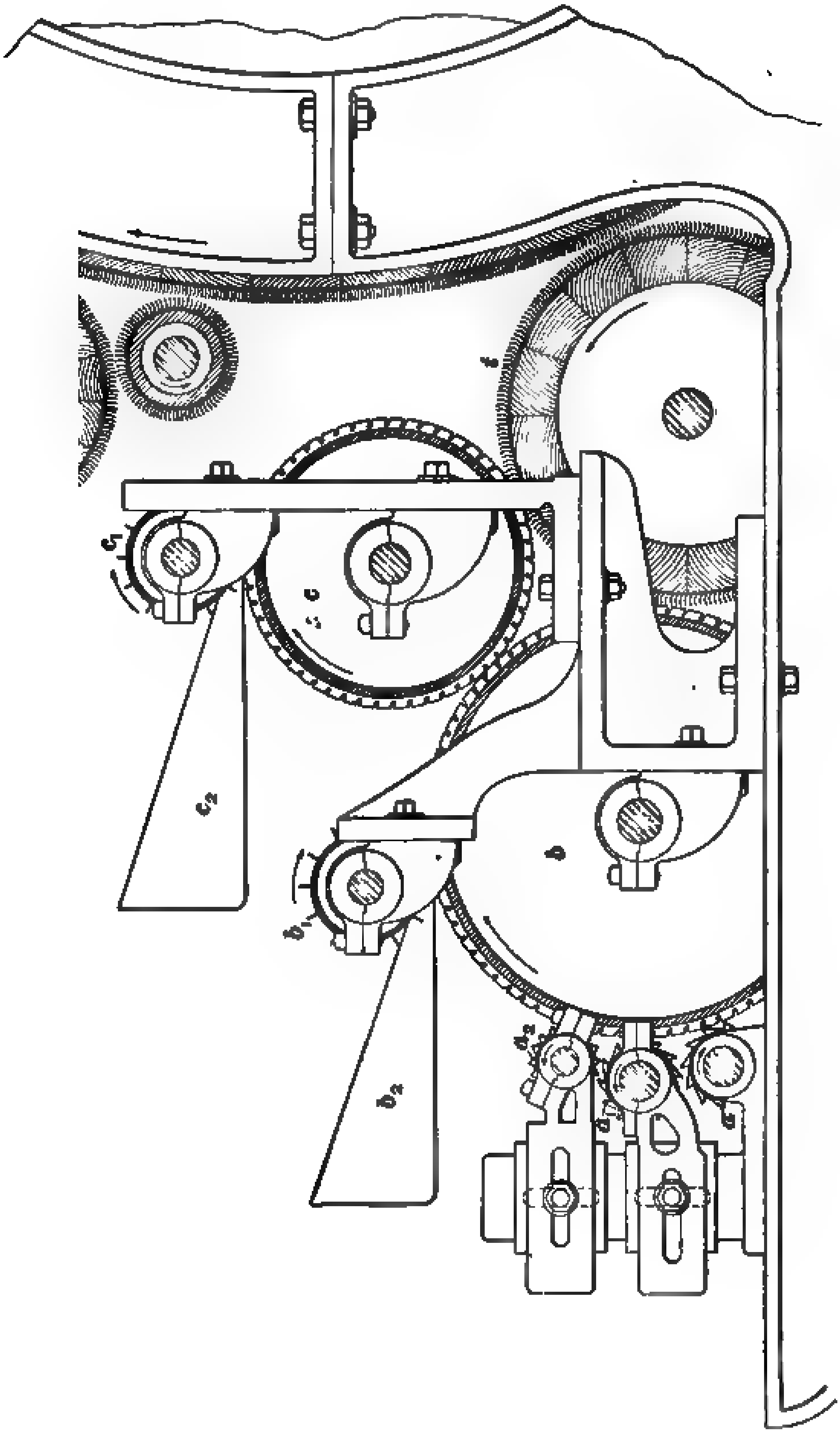


FIG. 14

Fig. 15

gradually opens the wool, so that none of the fibers are broken when taken by the swiftly revolving main cylinder of the card.

The metallic breast shown in Fig. 15 consists of two metallic feed-rolls a, a_1, which take the stock and pass it to a licker-in b, which is covered with Garnett wire and passes the stock to the metallic breast d. A small stripper a_2 keeps the bottom feed-roll clear, while a roll c, called the *breast roll*, cards the wool on the licker-in b and delivers such as is not retained by the licker-in to the breast, which is 16 inches in diameter and works in connection with three 6-inch workers f and three $2\frac{1}{4}$-inch strippers e in the same manner as the main cylinder works with the workers and strippers of the card. The stock is then taken by the tumbler of the card g and passed to the main cylinder. A breast cylinder should run at about one-fourth the surface speed of the main cylinder of the card. This metallic breast is also shown on the card, Fig. 15, *Woolen Carding*, Part 1.

EUROPEAN METHODS

22. The **European system** of carding wool for the production of woolen yarn differs somewhat from the American, especially in England, where it is the custom to use but two cards for this kind of carding; namely, a first breaker, or as it is there called a *scribbler*, or *breaker scribbler*, and a finisher.

The **breaker scribbler** in the English woolen trade takes the place of the American first and second breakers and consists of three distinct parts: First, a metallic breast, over which are placed two workers and two strippers and also a fancy; second, a large main cylinder, or *swift*, over which are placed four workers and four strippers and a fancy; and third, another cylinder with the same complement of rolls. There are also, in connection with the breast and with each of the swifts, doffers that take the wool from them after it has been operated on by the complement of workers, strippers, and fancy working in connection with each. A small stripper, known as an *angle stripper*, takes the wool from the doffer and passes it to the next cylinder, where the

operations of carding and stripping are repeated until the stock is finally removed from the last doffer by means of an oscillating comb.

The finisher card used in the English system of carding is similar to that used in America with the exception that a single ring doffer is generally used where the ring system is used at all. This doffer is of large diameter and is clothed with rings, the spaces between the rings being only about $\frac{3}{16}$ inch in width. In order that the wool shall not be left in strips on the main cylinder of the card when using a single doffer, the last worker, or perhaps the last two workers, are given a slight traversing motion so that they will pick up the stock on the cylinder not taken by the doffer and distribute it over the entire width of the card.

23. Difference Between European and American Systems.—It will be seen that the main difference between the American and European systems of carding is in the construction of the first breaker; the English and other European carders use a double first breaker and do away with the second breaker used in most American mills, although in some English mills on fine work they insert an extra card between the breaker scribbler and the finisher, but keep the first card as before.

A modification of the English system is sometimes used in American mills and consists of doing away with the intermediate balling head and creel between the first and second breakers and backing the second breaker up to the doffer of the first breaker, the transfer of the stock from one to the other being effected by means of the angle stripper. For carding low stock this makes a good arrangement and also causes a great saving in labor and floor space; but for fine stock it is not to be recommended, because with this method of coupling the cards there are no doublings between the first and second breakers, and in making fine yarn, or in fact any yarn, the more doublings there are, the evener and more uniform will be the resultant thread. This is, however, not important in coarse yarn, as a slight variation will not be noticed.

WORSTED CARDING

24. Difference Between Woolen and Worsted Carding.—It is unnecessary in these Sections to deal fully with **worsted carding**, as that subject would be out of place in the treatment of woolen carding, but a brief reference is made to worsted carding, so as to explain the principal points of difference between carding in the woolen and in the worsted trades. Wool is carded on two systems for the production of two classes of fabrics; namely, the worsted system of carding, for the manufacture of worsted yarns and fabrics, and woolen carding, for the manufacture of woolen yarns and fabrics. The two systems are different both in the machines used and the results obtained, although the principle of carding remains the same.

Worsted carding tends toward the parallelization of the fibers, while woolen carding is more for the purpose of making a uniform mix, or blend, of the fibers, than to parallelize them. The tendency of any carding process is to lay the fibers parallel, but upon a woolen card the stock is removed from the card by means of a side drawing, which tends to mix and cross the fibers; at the same time the side drawing is twisted by being passed through a rotating tube, which also has a tendency to mix the fibers of wool. From the worsted card the stock is removed in a web, passed directly through a stationary trumpet, and wound into a ball without twist, which tends to lay the fibers parallel to the direction of the drawing. This is the beginning of the parallelization of the fibers.

Again, the worsted carder deals generally with a longer fiber and this requires a slower speed, in order to guard against breakage and the consequent shortening of the fiber, while the woolen carder in dealing with a shorter fiber, which is more easily opened out and disentangled, can use higher speeds. Even if the fiber is broken, the deterioration

of the stock is not of so much consequence in the manufacture of a woolen as in the making of a worsted yarn, since all short fibers are removed by the comb in worsted-yarn manufacture and are, consequently, a dead loss so far as worsted is concerned, although they may be (and are, under the name of noils) used in woolen manufacture. Wool that is carded for worsted yarn is afterwards combed and put through various operations of drawing before spinning, while a woolen thread is spun on the woolen mule directly after the carding process. A woolen yarn is a thread spun from wool, the fibers of which are mixed and crossed in every conceivable direction and which presents a rough, although uniform, surface appearance. A worsted yarn is a thread spun from wool, the fibers of which lie smoothly in the direction of the thread and parallel to each other. From these definitions it will be seen that a woolen yarn differs from a worsted in the arrangement of the component fibers; also, generally speaking, in the length of the fibers and in the process of manufacture, which in woolen spinning tends to an even artificial mixing and in the worsted to parallelism of the fibers. Worsted carding is customarily performed on one card, which may be considered as a double card, being composed of two cylinders with their complements of workers, strippers, etc. The worsted card also usually carries, before the first cylinder, four licker-ins (or three licker-ins and a burr cylinder), and several other rolls. This, of course, makes a long card, which has a large amount of carding surface.

WOOLEN CARDING

(PART 3)

CARD CLOTHING

1. Card clothing, the material with which the various rolls of the card are covered and by means of which the wool or other stock is opened out and prepared for the spinning, consists of wire teeth set in leather or some other suitable foundation and having a bend, or forward inclination, from a point called the **knee** of the tooth. The foundation employed for woolen cards is generally leather, but on cotton and worsted cards various woven combinations are used.

Flexifort, a foundation largely used for worsted card clothing and frequently for woolen cards, consists of a woven fabric, generally cotton or cotton and wool but sometimes composed of cotton and linen, the face of which is covered with a veneering of india rubber. The india rubber gives a firm yet elastic foundation and is especially adapted for worsted carding, as this fiber is carded while moist; any dampness would rot either a cotton or a leather foundation for the clothing. On cotton cards combinations of wool and cotton are generally used for the clothing. Leather is generally used as the foundation of clothing for woolen cards. Rubber clothing cannot be used for woolen cards, as the oil that is applied to the wool will quickly weaken the rubber.

2. Wire.—Besides the foundation, several points in regard to the wire should be carefully noted: (1) Its character as to shape and preparation; (2) the angle at which it

passes through the leather; (3) the angle at the bend, or knee; (4) its size; (5) its setting in the foundation.

Card clothing is set with many kinds of wire—iron, steel, tempered steel, brass, tinned, etc.—but the best wire to use for woolen carding is the tempered steel, which makes a springy, elastic tooth that is not easily bent out of place. The wire is better if tinned, as then there is no liability of the clothing rusting during damp weather or if water is applied to the stock. *Round wire* is generally used, although another kind, known as the *elliptical wire*, which is made by

TABLE I

Birmingham		American	
No. of Wire	Diameter Inch	No. of Wire	Diameter Inch
28	.014	28	.012641
29	.013	29	.011257
30	.012	30	.010025
31	.010	31	.008928
32	.009	32	.007950
33	.008	33	.007080
34	.007	34	.006305
35	.005	35	.005615
36	.004	36	.005000

passing round wire through heavy rolls and slightly flattening it out, is sometimes used. *Triangular wire* has also been used, as well as the *diamond-point wire*, which is used for licker-in and feed-rolls.

Fine wire is more elastic than coarse wire and has a gentler action on the stock and also allows of a more open set of the clothing with the same number of points per square foot. If nothing but the wool to be carded comes in contact with the wire, fine wire will be found to be as durable as coarse, but the fine clothing will necessitate more careful handling and grinding. When a uniform quality of

stock is carded the clothing can be adapted to it; but where several kinds and qualities of wool are used, it is best to have the wire fine enough to handle the best quality of wool and the coarser kinds will not be injured, neither will the clothing with proper care.

Two gauges are commonly used for determining the number, or size, of wire; namely, the English, or Birmingham, and the American, or Brown & Sharpe. Table I shows the comparative sizes of the two systems. The card gauges used for determining the proximity of one roll of a card to another, such as the setting of the workers to the main cylinder, are also based on the same system as wire gauges.

The standard sizes of wire used on woolen cards are usually No. 33 wire, American gauge, for first breaker, No. 34 wire, American gauge, for second breaker, and No. 35 wire, American gauge, for finisher card. The fancy on each card is usually made one number coarser and the wire set more open. Doffers are sometimes covered with wire one number finer, while tumblers are usually clothed with coarser wire. This depends on the carder and is usually designated when ordering the cards.

3. The wire teeth are placed through the foundation by a machine that automatically cuts the wire and bends it in the form of a staple, pierces the holes in the foundation, thrusts the wire through, and then makes the knee, or forward bend. The wire is not passed straight through the foundation but at an angle opposite to that of the forward inclination of the tooth; this angle is very slight and serves to offset the bend at the knee of the tooth. This is shown in Fig. 1, which also shows the forward bend of the wire. The wire passes through the leather foundation *a* at an angle and is bent forwards again at the knee *b* until the point *c* touches the perpendicular *de*, which is drawn from the point where the wire issues from the foundation.

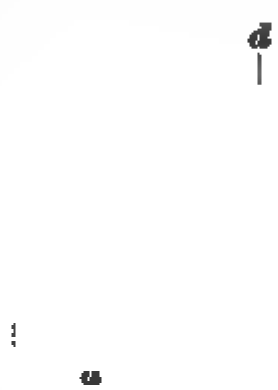


FIG. 1

The tooth should not be bent forwards past the perpendicular to any great extent; for if it is, the point will rise when the strain comes on the tooth, owing to the arc in which the tooth moves, as the wire is not held perfectly rigid, but a certain amount of play is allowed, owing to the flexible nature of the foundation and of the wire. Thus, if the tooth is inclined forwards past the perpendicular line, the strain on it when carding will raise its point and make the setting of the card closer; that is, the slight raising of the point will have the same effect as setting the rolls nearer to each other. On the other hand, if the point of the tooth just reaches the perpendicular, any strain on the tooth will have the effect of depressing the point; this will increase the distance between the rolls or make the setting more open, thus easing the strain.

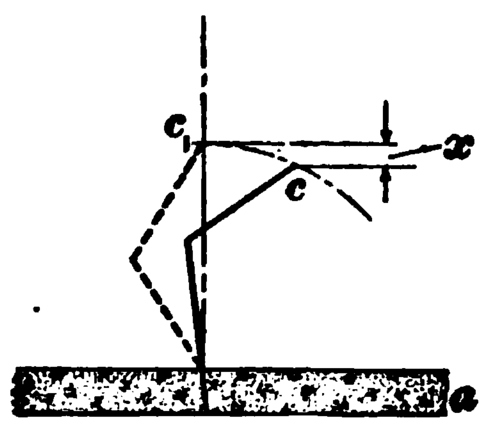


FIG. 2

In order to make this clear, reference is made to Fig. 2; if the tooth were pushed from c to c_1, its point would be raised the distance x, which in some cases might be sufficient to put it in contact with another roll. Besides, there is a tendency of the tooth to straighten at the knee, which will also have the effect of raising the point.

4. Clothing for Workers and Strippers.—Fig. 1 shows the general proportions of clothing suitable for the workers and strippers of a woolen card. It will be noticed that the distance between the knee and the foundation of the clothing is just a trifle shorter than that between the point of the tooth and the knee. This is about the right place for the forward bend of an ordinary working tooth to commence. The nearer the knee is to the point of the tooth, the stronger will be the clothing and the more tenaciously will it hold the fibers of the stock; on the other hand, the nearer the knee is to the base of the tooth or the foundation of the clothing, the more flexible will be the clothing and the more will its action resemble that of a brush.

5. Clothing for the Fancy.—*Fig.* 3 shows a section of a piece of card clothing such as is used for covering the fancy. The wire is longer than the ordinary tooth and more flexible, and the knee is lower, because the fancy is set into the teeth of the main cylinder and acts as a brush. The knee is often made even lower than is shown. It will be noticed that the point of the tooth of the fancy clothing in the illustration projects beyond the perpendicular. This is not a disadvantage unless the bend is extreme, for as the teeth on this roll do not engage with the wool, there is no danger of the point of the tooth being lifted, owing to the direction of rotation and surface speed of the fancy; however, if the bend at the knee is extreme, the fancy will pack the main cylinder with wool.

FIG. 3

Straight wire is sometimes used for the fancy, but it often has a tendency to make a large amount of flyings by throwing the wool from the cylinder, especially if the clothing is applied with considerable tension and the fancy is not speeded just right.

SHEET AND FILLET CLOTHING

6. There are, generally speaking, two varieties of card clothing–*sheet* and *fillet*, or *filleting*. The sheet clothing is manufactured in sheets 5 inches wide and as long as the width of the card on which they are to be used. Fillet clothing is made in long, continuous strips, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, or 2 inches wide; it is wound continuously around the roll to be covered.

Sheet clothing is commonly used on the main cylinders, while filleting is used for all other rolls of the card, except those covered with metallic clothing and the finisher doffers, which are covered with rings of clothing that are slipped on and spaced evenly apart. The finisher cylinder is sometimes covered with filleting, which is to be preferred. The teeth are set into sheet clothing so that their crowns—the parts of

the teeth on the back side of the clothing—are *twilled;* that is, they are set in diagonal lines like a piece of twilled cloth. Sometimes sheet clothing is made *plain set*, that is, with the crown of the teeth overlapping in the same manner as bricks are laid; although this form has been extensively adopted in England, it is not generally used in America. Here most of the cards are clothed with 8-crown twilled clothing. Fillet clothing is always *rib-set;* that is, the teeth are so inserted through the foundation that the crowns form ribs on the back running lengthwise of the fillet; the teeth in

FIG. 4

rib-set clothing may be either twill set or plain set. To find the crown of a piece of clothing, the number of crowns, or backs, of teeth in 1 inch of two rows should be counted. Therefore, 8-crown clothing would contain 4 crowns per inch across the clothing, but there would be eight points per inch in one row on the face of the clothing, as there are two points to every crown. The piece of sheet clothing shown in Fig. 4 is 8-crown clothing, having 4 crowns per inch. Fancy clothing is more open, being usually set with 4 crowns for fillet $1\frac{1}{8}$ inches wide.

7. The **nogg** is the distance between the first tooth of one line of twill and the first tooth of the next line; thus, if as in Fig. 4 the clothing has a 6-twill, there are 6 teeth per nogg. If more points per square foot are wanted, the number of noggs per inch is increased; if less points are desired, the number of noggs is reduced. The noggs run crosswise of the sheets of sheet clothing and lengthwise of the strip of fillet clothing. After either sheet or fillet clothing is applied to the card, the noggs always run around the rolls, while the crowns extend from side to side of the card.

CALCULATIONS

8. To find the number of points per square foot in card clothing:

Rule.—*Multiply the number of crowns per inch by the number of noggs per inch, by the number of teeth per nogg, by the number of points per tooth* (2), *and by the number of square inches in a square foot* (144).

EXAMPLE.—Find the number of points per square foot in the sample of card clothing shown in Fig. 4, the number of crowns per inch being 4, the number of teeth per nogg 6, and the number of noggs per inch 8.

SOLUTION.—

Number of crowns per inch . . .	4
Number of noggs per inch . . .	8
	32
Number of teeth per nogg . . .	6
	192
Number of points per tooth . . .	2
	384
Number of inches per square foot	144
	1536
	1536
	384
	55296 points per sq. ft. Ans.

When the number of points per square foot is divided by the number of noggs per inch, it will be noticed that, with

8-crown clothing (4 crowns per inch), each nogg increases the number of points per square foot by 6,912, thus: $\frac{55296}{8} = 6{,}912$. From this it will be seen that in order to find the number of points per square foot in 8-crown (4 crowns per inch) sheet clothing, it is only necessary to multiply the number of noggs per inch by 6,912.

Fig. 5 shows a piece of 1½-inch rib-set fillet that is made 8-crown, the same as sheet clothing; however, fillet clothing

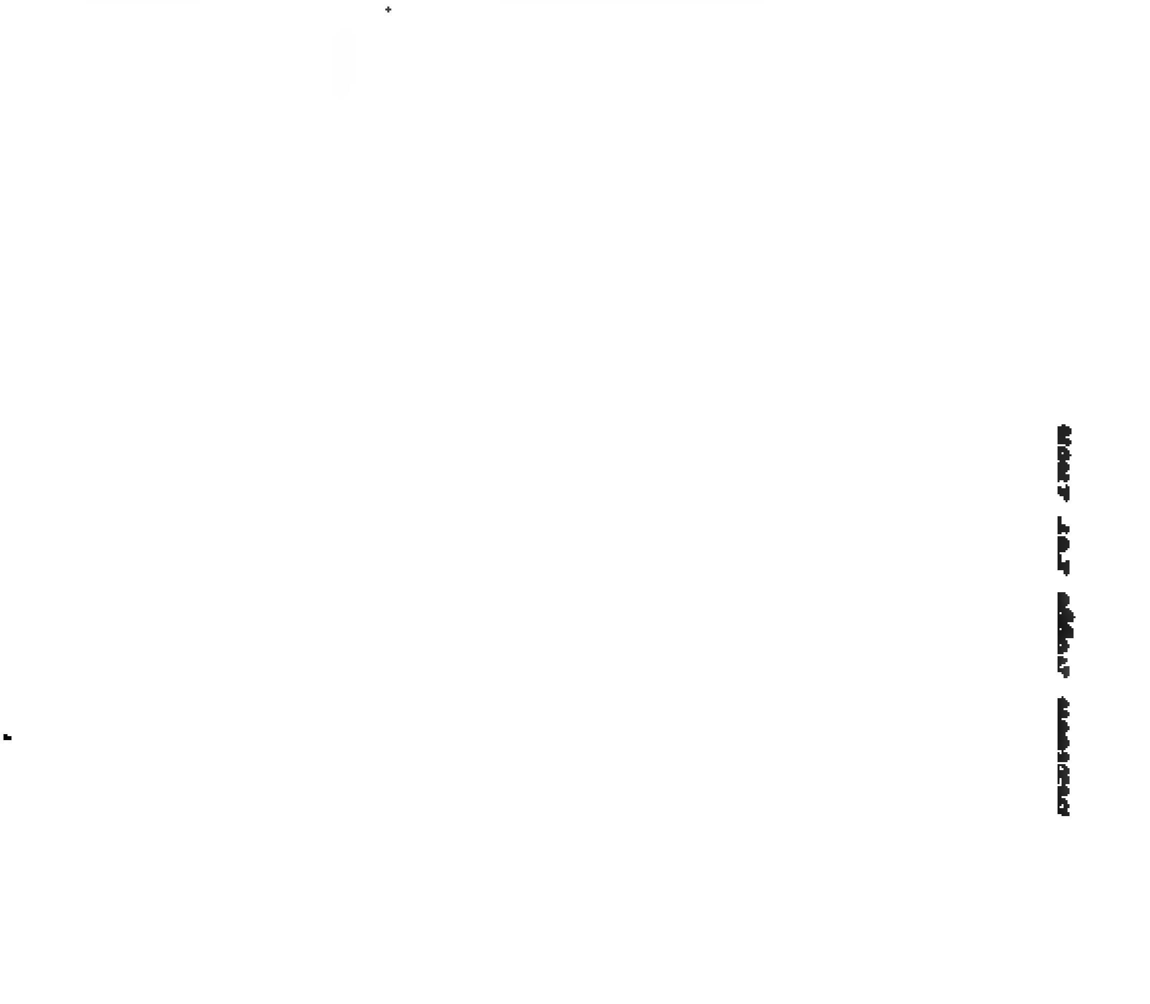


FIG. 5

is set for the same size of wire with twice the number of noggs per inch and one-half the number of teeth per nogg.

9. The rule for finding the number of points per square foot in fillet clothing is the same as for sheet clothing.

EXAMPLE.—If the fillet shown in Fig. 5 has 4 crowns per inch, 16 noggs per inch, and 3 teeth per nogg, what is the number of points per square foot on the face of clothing?

SOLUTION.—

Number of crowns per inch . . .	4
Number of noggs per inch . . .	16
	64
Number of teeth per nogg . . .	3
	192
Number of points per tooth . . .	2
	384
Number of inches per square foot	144
	1536
	1536
	384
	55296 points per sq. ft. Ans.

When the number of points per square foot is divided by the number of noggs per inch, it will be noticed that each nogg in 8-crown fillet clothing increases the number of points per square foot by 3,456. From this it will be seen that in order to find the number of points per square foot in 8-crown fillet clothing it is only necessary to multiply the number of noggs per inch by 3,456.

The following tables show the number of points per souare foot for different-sized wire that are regarded as the standard number for 8-crown clothing (4 crowns per inch) and orders for any number of wire are usually filled by manufacturers in accordance with them:

TABLE II

SHEETS

No. of Wire	Noggs per Inch	No. of Points per Square Foot
28	5	34,560
30	6	41,472
32	7	48,384
33	8	55,296
34	9	62,208
35	10	69,120
36	11	76,032

TABLE III

FILLETING

No. of Wire	Noggs per Inch	No. of Points per Square Foot
28	10	34,560
30	12	41,472
32	14	48,384
33	16	55,296
34	18	62,208
35	20	69,120
36	22	76,032

TABLE IV

FANCY FILLETING

No. of Wire	Noggs per Inch	No. of Points per Square Foot
28	10	23,040
30	11	25,344
32	12	27,648
33	13	29,952
34	15	34,560
35	16	36,864
36	17	39,168

CARE OF CARDS

SETTING CARDS

10. The **setting** of cards is the adjustment of one roll to another in order that each roll may have its proper action on the stock as it passes through the card. The various parts of the card are set according to the work that is being run and the condition of the stock when it comes under their action. If a card is set too open, the wool will not be properly carded or opened out; if it is set too close, especially on the first breaker card, where the wool is not so well opened as on the other cards, there is a liability of the fibers being broken or cut and the value of the spinning properties of the wool materially reduced. The setting of the first breaker should be more open than that of the second, owing to its receiving the stock in almost its natural condition and having to perform the first opening of the wool fibers; as the wool is being constantly opened the finisher may be set closer than the second breaker.

11. **Gauges.**—Formerly it was customary to set cards by the eye and ear alone, but owing to the fact that the light struck at varying angles on the card clothing, the settings

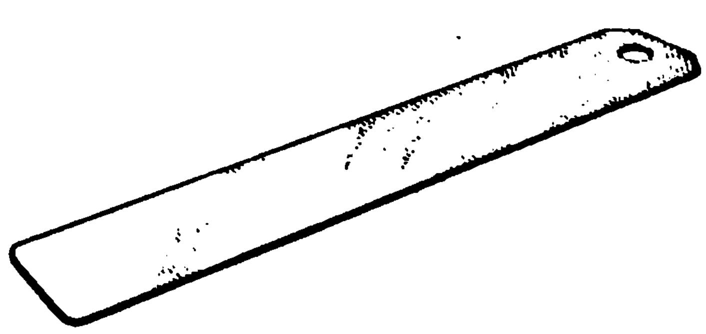


FIG. 6

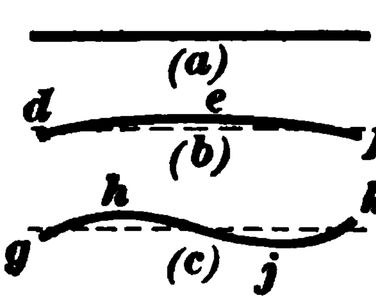


FIG. 7

were never really accurate. The setting is now accomplished by means of **gauges**, shown in Fig. 6; these are flat strips of tempered steel about $1\frac{1}{4}$ inches wide, 7 or 8 inches long, and varying in thickness according to a given standard. They

should be accurate and when made by a reliable maker will be found to be of uniform thickness. The standard adopted for their thickness is the same as that used for the standard sizes of wire, so that the thickness of a No. 30 gauge is the same as the diameter of a No. 30 wire.

Although the most exact settings are obtained by means of card gauges, after being used for some time almost all gauges are found to have been bent crosswise and, instead of being perfectly flat, as shown in Fig. 7 (*a*), they become shaped as shown in Fig. 7 (*b*) and (*c*) and, consequently, touch at points *d*, *e*, and *f* in Fig. 7 (*b*) and *g*, *h*, *j*, and *k* in Fig. 7 (*c*).

While the thinner gauges, if bent in the shapes shown in Fig. 7 (*b*) and (*c*), will straighten somewhat when introduced between the rolls of the card if a tight fit is obtained, it has been found from numerous observations and tests that the thickness of the gauge is always exceeded. The thicker gauges, such as Nos. 24 or 26, when bent as shown in Fig. 7 (*b*) and (*c*), scarcely yield at all when used in setting and a large percentage of error is consequently introduced. This will cause the parts of the card to be set farther from each other than the indicated thickness of the gauge. Home-made or damaged gauges are never accurate, and should not be used except for feed-rolls or burr cylinders.

12. The points at which the distance between the rolls of the woolen card need to be adjusted, or set, are the following: Between the top and bottom feed-roll; between the burr cylinder, or licker-in, and feed-rolls; between the burr cylinder, or licker-in, and the burr guard, or licker-in fancy; between the burr cylinder, or licker-in, and the tumbler; between the tumbler and the main cylinder; between the main cylinder and the strippers; between the main cylinder and workers; between the workers and strippers; between the main cylinder and fancy; between the main cylinder and the doffer or ring doffers; between the doffer and the doffer comb. On the condenser the setting of the wipe roll to the doffers and the proximity of the rub aprons must also be regulated.

The setting of the various parts, as designated above, must necessarily vary according to conditions. The length of the fiber is one important element; the longer the fiber, the more open must be the settings. Then, again, the condition of the wool as it comes to the first breaker must be considered; if it is matted, the setting must be more open on the first two or three workers of the first breaker in order not to bend the clothing by trying to open out the stock at once. With such stock it is sometimes a good plan to set the workers progressively on the first breaker, but if the stock is well opened and lofty the card may be set close.

Although the first breaker must be set more open than the other cards, it must not be set too open, because when the wool leaves the first breaker it must be well carded, as it is on the condition of the wool, when it leaves this card, that the ultimate result of the carding largely depends. The carder, therefore, is always careful of the first breaker and sees that it turns out the stock in a lofty sliver, free from specks or neps as far as possible; otherwise, a great amount of additional care on the second breaker and finisher cards will be required.

The second breaker card is always set finer, or closer, than the first and the finisher closer than the second breaker, in order to card the stock thoroughly fiber from fiber. After each carding, the wool is more open and separated, and thus allows closer adjustments of the working parts without breaking the fibers of wool.

Before setting the card care should be taken to have all belts in place, for if the card is set with the belts off, the settings will be disturbed when they are placed in position. When setting workers and strippers, care should be taken to remove any dirt or flyings from between the bearing and the shaft, if an open bearing is used.

Only one end of a gauge is ground accurately to the indicated thickness, so that in setting the different parts of the card to each other the opposite end, which is the one with the hole in it, should be grasped and the gauge inserted between the rolls for a distance equal to barely one-half of

its length. It should then be moved slowly back and forth across the card and the proximity of the rolls varied until a correct setting is obtained.

One side of the card should be set first, regulating the distance between the rolls so that the gauge will slip between them readily, neither binding nor being too loose, but simply requiring an easy but firm pressure to move it along between the rolls. Then the other side of the card should be set in the same manner.

After both sides of the card are set, the side that was adjusted first should be gone over again, as the setting of the other side of the card always disturbs the original setting more or less. On very particular work some carders go over a card several times.

AVERAGE SETTINGS

13. Setting the First Breaker.—Although the setting of the card depends largely on the stock being carded and the judgment of the carder, the following will be found to be average settings of ordinary woolen cards on from 4- to 6-run work. The adjustable bearings of the rolls of a card, except the workers and strippers, are carried on slides and are adjusted by means of screws that have circular heads with holes drilled in them. In order to turn the screw a small *set* is inserted into the hole and the screw turned, after the bolts that hold the bearings have been loosened. The adjustment screws are usually provided with check-nuts. For setting the feed-rolls of the first breaker to each other and for setting the burr cylinder to the feed-rolls and also between the burr cylinder and tumbler and between the burr cylinder and burr guard a coarse gauge, about No. 22 or 24, is generally used. This gauge is kept for this purpose and is usually an old or damaged one, as setting burr cylinders and feed-rolls injures the gauges. The setting of these parts is not so important as that of the working parts, such as the tumbler, workers, strippers, doffer, etc., to the main cylinder, which may be set with a No. 26 gauge. The doffer

should be set slightly closer to the main cylinder. This may be done by pressing it tighter on the gauge when setting or by using a finer gauge. Although the fancy is usually set by ear alone, it is better to use a gauge and judge the depth of the setting by the pressure required to force it between the fancy and the main cylinder. The teeth on the fancy should dip slightly into the teeth on the main cylinder, probably about $\frac{1}{32}$ inch, although this is never measured; the fancy is set and then turned by hand, its depth being judged by the whiz it makes in rubbing through the clothing of the cylinder. The fancy usually needs adjustment after the card is running, in order to make it handle different stock successfully, being set either off or on as the occasion demands. The doffer comb should be set as close to the doffer as possible without striking.

14. Setting the Second Breaker.—The second breaker is set similar to the first except that the setting is closer, being set to about a No. 28 gauge throughout. The feed-roll stripper in the second breaker should be set quite close so as to keep the top feed-roll clear. The licker-in fancy should be set so as to dip slightly into the licker-in wire in order to keep it clean and clear from short fibers of wool.

15. Setting the Finisher Card.—The finest settings are made on the finisher card when a No. 30 gauge is used. The ring doffers of the finisher should be set very close to the main cylinder in order to strip the stock thoroughly from the cylinder. A No. 32 gauge is often employed for setting the ring doffers.

16. Setting the Condenser.—The wipe roll of the condenser is usually set to the ring doffers with about a No. 22 gauge. The teeth in the gear on the end of the wipe roll should intersect about half their depth when the wipe roll is set to the aprons. The distance between the under side of the wipe roll and the top of the bottom rub apron should be sufficient to allow the roving to clear properly, since if this distance is not great enough the vibration of the rub apron will rub the roving against the surface of the wipe roll,

which does not vibrate, and thus cause the roving to be split. The wipe roll should be as close as possible to the top apron and still not touch it. These points should be carefully noted, for if either of the vibrating rub aprons come in contact with the wipe roll, twitty roving will be made.

The distance between the rub aprons on the Davis & Furber double-apron condenser is regulated by small slotted pieces of sheet iron that are slipped between the bearings of the apron rolls and the frame of the condenser. These packings are usually one of two thicknesses, $\frac{1}{16}$ inch or $\frac{1}{8}$ inch, but the $\frac{1}{8}$ inch packing is ordinarily used. For coarse wool, both packings are placed in position so that the space between the rub aprons is about $\frac{1}{32}$ inch. For medium work, the packing on the lower rub apron is removed so that the space at the front of the top and bottom rub aprons is about $\frac{5}{32}$ of an inch; this allows a slightly less rubbing action. For fine work where a less amount of rubbing action is required, both packings are removed so that a space of about $\frac{9}{32}$ inch is left between the top and bottom rub aprons at the front, while at the back part of the aprons a slight rubbing action is given. The pair of rub aprons of each deck nearest the ring doffers are generally adjusted so that there is a uniform distance or about $\frac{1}{32}$ inch between them. The throw of the eccentrics that cause the vibrations of the rub aprons should be so adjusted as to be slightly in excess of the width of the rings on the doffers. For instance, if the rings on the doffers are 1 inch in width, then the throw of the eccentrics should be adjusted so as to be about $1\frac{1}{16}$ inches.

The amount of rubbing that is imparted to the stock can be varied by altering the speeds of the eccentrics. The faster the aprons are made to traverse, the greater will be the rubbing action. Defective work is often made by the speed of the eccentrics being so slow that the ribbons of wool cannot be rubbed into roving by the rub aprons as fast as they are delivered by the wipe roll. When using a condenser with screw adjustments, both sides of the aprons should be carefully set, in order that no variation in the distance between the aprons at each end shall exist.

17. Setting Workers and Strippers.—The method of setting the workers and strippers will be readily understood by referring to the illustration of the first breaker in *Woolen Carding*, Part 1. In this illustration, the poppet heads that carry the shafts of the strippers and workers extend through sleeves attached to the arch of the card and also pass through a flange on the arch, being held in position by two checknuts, one on each side of the flange. In order to set the worker or stripper closer to the main cylinder, the top checknut should be loosened and the bottom nut tightened. To set the worker or stripper farther from the main cylinder, the bottom nut should be loosened and the top nut tightened.

When setting workers and strippers or other rolls to a cylinder covered with sheet clothing, the cylinder should be moved so that the adjustment will take place at the center of a sheet and not on the edge, because nearly all sheets are slightly higher in the center and if the worker is set on the edge of the sheet there is some liability of contact with the highest part of the sheet. Sheets are apt to grow higher in the center as the clothing wears and is stretched by the strain during carding. This tendency is aggravated by the centrifugal force of the rapidly rotating cylinder, which tends to throw the clothing away from its center, especially if it is loose.

The sleeves through which the supports for the worker bearings pass are larger than the sleeves through which the supports for the stripper poppet heads pass and allow a lateral movement for adjusting the worker to the stripper. This movement is governed by two screws that are threaded into the sleeve and press against the support of the worker bearings. After the proper adjustment is obtained, both screws should be carefully tightened.

18. Setting the Doffer.—In setting the doffer, the fancy may be taken out in order that a clear view may be had and the distance accurately gauged all the way across. The main cylinder, as well as the doffer, should be turned

into various positions and at each movement carefully tried with the gauge, so as to be perfectly sure that when the card is in operation there will be no contact between the two. It is important when setting the doffer to have the worker belt in position, for if this is neglected it may raise the doffer slightly in its bearings, and so bring the doffer too close to the main cylinder and destroy the points of both.

19. Setting the Fancy.—More trouble is usually experienced with the fancy than with any other part of a woolen card. The fancy is the only roll of the card that is set with the belt off. This is necessary, because, in setting, the fancy is made to revolve by hand and the depth of the setting judged by the sound produced by the fancy wire passing through the cylinder clothing. After it has been set and the stock is on the card, it is often necessary to change its setting, for if not properly set for a given stock, the fancy will either throw the stock out of the card or else choke up, or lap; or it may pack the main cylinder. When the fancy is throwing the stock, it is usually set too hard into the cylinder or else is speeded too fast, or the teeth may be too straight and stiff. It often laps with wool because its clothing is rough, or because its speed is too slow. When a fancy is working right, the wool is lifted to the points of the cylinder clothing uniformly and thus can be readily taken by the doffer.

The surface velocity of the fancy should only be slightly in excess of the surface velocity of the cylinder. To find the relative surface velocities of the main cylinder and fancy, turn the cylinder over once and count the rotations of the fancy; then multiply the circumference of the fancy by the number of times that it rotates to one turn of the cylinder. The circumference of the cylinder should be to this product as about 4 to 5 if the fancy is speeded right.

20. The settings previously given should not be regarded as absolute, as in woolen carding there is a wide range of variation in card setting, and as no two conditions are the same, no hard and fast rule can be laid down. Some carders

set as fine as a No. 32 gauge on the first breaker, No. 33 on the second breaker, and No. 34 on the finisher card, with the ring doffers set to perhaps a No. 35 gauge. This, however, is an extreme case and is only possible when the cards are in excellent condition and the stock very fine. Other carders working on a similar grade of wool may use Nos. 28, 30, and 32 gauges. Again, cards are frequently set much more open, as, for instance, a No. 22 gauge on the first breaker, No. 26 gauge on the second breaker, and No. 28 gauge on the finisher. Much depends on the carder, the previous preparation of the stock, and the condition of the cards; a variation of a point or two in setting is of no material difference, provided that the wool is well carded. The main point to be observed is the condition of the stock as it leaves the card. Take the sliver from the first breaker and pull it apart, holding it toward the light; it can readily be seen whether the card is operating on the wool satisfactorily or whether the sliver is full of specks or neps that are not opened out. The sliver from the second breaker should be examined in the same way and if the wool is not free from specks the cards may be gone over and set closer.

The carder must use judgment in setting his cards and take into consideration the wool being worked and also the number of yarn to be spun. If the setting is too close, the wool is cut or the fiber broken; if too open, the stock is not opened and is liable to be rolled into bunches. The settings should avoid these extremes and yet be as open as possible to card the stock properly; if set finer than necessary, the treatment of the wool is more severe than is needful.

Some carders set progressively; that is, they begin with the first worker in the first breaker card, which is set open; the setting then grows finer until the ring doffers are reached. Such an adjustment might begin with a No. 22 gauge with the first worker and end with a No. 34 between the finisher cylinder and the ring doffers.

In some mills it is customary to set strippers one point finer both to the main cylinder and to the workers. Strippers

are never set progressively as above explained, the progression being between the workers and the main cylinders and the main cylinders and doffers, which are the working points of the cards.

STRIPPING CARDS

21. From time to time the clothing of the cards becomes so choked and filled with short fibers, dirt, dust, shives, grease, and other matter that has been removed from the carded wool that the operation of carding is seriously affected; from this arises the necessity of cleaning, or as it is called, **stripping** the cards. Some stock contains much refuse matter and other dirt and quickly fills up the card; other stock, being comparatively clean, will allow the card to run for a much longer time without cleaning. Less cleaning is required, therefore, if the stock is prepared for the cards in the best manner and as thoroughly cleaned of foreign matter as possible.

22. Time of Stripping.—The first breaker needs more cleaning than the second breaker card and the second breaker needs more than the finisher, for as the wool proceeds much of the dirt is being constantly removed. Generally speaking, the first breaker should be cleaned every day; in some mills, to economize time, it is customary to clean the main cylinder and doffer one day and the whole card the next. The second breaker may be cleaned every other day, cleaning the cylinder and doffer and the whole card alternately. The finisher card may be stripped twice a week on low stock, cylinder and doffers and all through alternately, and once a week on fine stock. It may be necessary to clean the ring doffers oftener than this. It must be remembered that when the second breaker or finisher card is stopped, the production of the set is also at a standstill. With the first breaker the case is changed as, if there is a sufficient number of balls ahead to supply the second breaker creel, the production will not be checked.

If the plan of cleaning the cylinder and doffer and the whole card alternately is adopted, care should be taken not

to clean two cards of a single set all through at the same time in order to avoid making a large number of thin rovings. These when made should be pulled from the jack-spool and placed in the hopper of the first breaker self-feed. Many mills clean the card all through each time, which is the best way, although the alternate plan saves much time and is fairly satisfactory.

It is necessary that the doffer should always be kept clean in order to remove the stock from the main cylinder. In England, it is customary to run a small conditioning roll, called a *dickey*, over the doffer, which keeps the doffer wire clean and in good condition.

The above statements will give some idea of the average time a card will run before cleaning, but no hard-and-fast rule for the cleaning can be laid down. It is customary in some mills to clean the cards periodically whether they require it or not, thereby making unnecessary waste or else allowing the card to run longer than it should without cleaning; a better plan is to look over the cards twice a day and have such cards or such parts as require it cleaned, thus making allowance for different kinds of stock.

23. Method of Stripping.—When the card is to be stripped the belts are thrown off and the stripping performed by means of hand cards. Two men are employed to strip a card, one working on each side of the card, in this manner the work being more advantageously accomplished. The usual method of stripping is as follows:

The belt is first thrown off from the self-feed, if the first breaker is to be cleaned, and the feed-rolls of the card disconnected by means of the small lever that throws the side shaft out of gear. The card is then allowed to run 4 or 5 minutes in order to allow it to clean itself as much as possible. The belts are then removed and the fancy taken from its bearings and placed in a rack, where the dirt is removed from it by means of a hand card or a comb. Two pieces of pipe are used in removing the fancy and the workers and strippers. These are slipped over the ends of the shaft and

the roll lifted out of the card by two men without any danger of dropping it, as is otherwise liable to occur owing to the grease on its shaft. Care must always be taken when removing any roll of the card not to damage the clothing, which if bent and bruised will not properly perform its functions.

The last worker is then taken out and placed in the empty fancy box and stripped, after which it is laid either on the floor or, preferably, in a rack. The same process is then carried out with the strippers and the rest of the workers, except that, in some cases, after two workers and two strippers have been removed the rest are stripped in their positions. Sometimes after the last pair of workers and strippers—the pair nearest the fancy, which are the first cleaned—have been placed in the rack, the others are brought back to the fancy boxes and stripped and are then immediately returned to their positions. Care should be taken to replace the rolls in their original positions and not interchange the workers and strippers; their numbers are generally stamped on the shafts by the makers.

The main cylinder and doffer are necessarily stripped in their bearings, as are also the licker-in and tumbler. The licker-in fancy, feed-rolls, and feed-roll stripper should be carefully cleaned, as well as the doffer comb, each time the card is stripped. After the card has been thoroughly cleaned, the rolls should be placed back in position and the belts replaced.

The card may now be allowed to run empty for 4 or 5 minutes, in order to remove loose particles of refuse that may be resting on the surface of the clothing, after which it is a good plan to run over the settings and change such as may be found inaccurate, being careful, however, that there are no particles of waste wool or other substances under the bearings.

The card may now be put in operation and the wool allowed to enter by putting the feed-rolls in gear again, but it must be allowed to run for 4 or 5 minutes after this in order that it may become filled with wool to its utmost

capacity and the sliver, or side drawing, attain its original weight before the product of the card is passed on to make roving. If this is not done the rovings made just after stripping will be thin and light and will not spin to the right number of yarn. The weight is apt to be a little light on the card for an hour or two after the stripping, but this of course is not returned to the self-feed but is spun, although perhaps the draft in the mule may have to be changed slightly to make the required number of yarn.

For stripping the ring doffers of the finisher card a special hand card of about No. 34 wire should be used; it should be used only for this purpose. Two men will keep from eight to twelve sets of cards clean, varying of course according to the stock, whether low or fine, and also according to its previous preparation.

GRINDING

24. Although **grinding,** or sharpening, the card clothing is frequently performed too often and at other times continued too long, there can be no doubt that at times the cards need grinding to replace the points of the teeth that have become worn or dull by abrasion or accident. Cards are usually ground too often where hardened and tempered wire is used; more frequent grinding is necessary on cards covered with mild wire, which is soft.

In some districts of Europe it is customary to grind the cards two or three times a month. This is wrong, for if the cards are properly set and cared for, there should be no necessity oftener than once in 3 months, and many times a card will run 6 or 8 months or even a year without grinding. More card clothing is spoiled by grinding too often and by overgrinding than work spoiled by dull cards.

Two kinds of points are obtained by grinding. The **chisel point** is the point put on the tooth by a roller emery grinder that has no traverse. This form of grinder grinds down the top of the tooth to a flat, or chisel, edge, while the traverse grinder, which grinds the tooth on each side as well as on the top, owing to the traverse of the roll, produces

what is known as a **needle point.** It must be understood that the term *needle point* does not mean that the wire is pointed the same as a needle or that it is nearly so sharp. The term is simply one of distinction between the flat, or chisel, point and the more rounded point due to grinding the wire on two sides and on the top.

While it is important that the clothing shall be sharp, it is also important that the teeth shall be smooth, since any roughness of the tooth is liable to cause it to catch and break the fibers.

One of the worst things that can happen to clothing is the formation of a **hook, or burr, point.** This sometimes happens when the grinding is continued too long or when the grinding roll is pressed too heavily on the clothing, thus turning over the point of the tooth and making a burr on the under side. When clothing is injured in this manner, the wool is with difficulty transferred from one roll of the card to another and the fancy also lifts the stock from the main cylinder with difficulty. When grinding, it is always better to grind lightly and rapidly than to grind slowly and with heavier pressure. Heavy grinding is liable to heat the wire and draw its temper.

IMPORTANT POINTS IN GRINDING

25. The different rolls of the card need varying degrees of attention in regard to grinding; some parts of the card need to be sharper and in better condition than others, which may require only smoothness to perform their functions. The main cylinder of the card after being once ground sharp will keep in good condition for some time, especially if the fancy works properly, since if set into the teeth of the main cylinder to a reasonable depth, it will keep the points of the same smoothness and in good working order by reason of the abrasion of the teeth against each other. The main cylinder needs to be smooth and true rather than extremely sharp, as this latter condition in a measure defeats the action of the workers and of the doffer by having

a tendency to hold the stock instead of allowing it to be transferred to those rolls.

The fancy is required to be perfectly true and should be smooth above all, for if the teeth are rough, it has a tendency to throw the stock from the main cylinder, thus making an increased percentage of waste in the form of flyings. Great care should be taken in grinding the fancy, and the grinding roll should only be allowed to touch it lightly, as the long, flexible teeth are liable to injury. After the fancy is ground it should be placed in the card and set well into the main cylinder, about $\frac{1}{8}$ inch. After being allowed to run into the cylinder in this manner for about $\frac{1}{2}$ hour it should be set off to its normal position and allowed to run a little longer. A hand card may be freely sprinkled with oil and held on the fancy while it is running on the main cylinder. By this means both the fancy and the main cylinder are made smooth and put in the best working order. Some fancy clothing, being made with a straight tooth with no bend at the knee, requires especial care in grinding in order that the teeth will not be bent or injured.

Workers must be kept sharp and true in order to card and open the wool, and also in order to take the stock from the main cylinder. The worker should always have a sharper point than the cylinder for this reason. In England, it is customary to set the strippers into the workers until a slight whizzing sound, caused by the contact of the teeth, is heard. The object of this is to keep the worker wire in good condition, the rubbing action of the stripper being to sharpen and smooth the worker. When grinding workers, care should be taken to avoid forming a burr on the wire, the tendency being to overgrind the roll while endeavoring to obtain as sharp a point as possible.

The strippers are simply conveyers of the wool from the workers to the main cylinder and should be kept smooth rather than sharp. Strippers are usually $2\frac{1}{2}$ or 3 inches in diameter and owing to this small diameter, the teeth are spread apart more by being projected from a surface bent around so small a circle. This makes it necessary to exercise

some care in grinding or the teeth will be bent out of shape.

The doffer is one of the most important parts of the card and should always be kept sharp and in good condition. It should always be smooth as well as sharp and the nearer it is set to the cylinder, the better it will work, provided that there is no contact between the two. The doffer should be sharper than the main cylinder in order readily to take the wool from the latter.

Before grinding, the card should be thoroughly cleaned and all places where the clothing is damaged should be remedied. The bent teeth are raised into position by means of a small steel blade provided for the purpose, or with a jack-knife.

TRAVERSE GRINDER

26. The main cylinder and doffer should be ground at the same time and without being removed from the card, which may be accomplished by means of a **traverse grinder**; the one shown in Fig. 8 is known as the Roy traverse grinder.

Fig. 9, which is a section of this grinder, shows that it consists primarily of a steel shell *f*, on which a sliding, or traversing, grinding wheel *h* is mounted.

Attached to this wheel is a slotted T piece *a* that extends through a slot cut the entire length of the shell and, by means of a dog *b* attached to the chain *k*, imparts the traversing motion to the wheel. The dog *b* is really a stud link, since it forms one part, or link, of the chain. The chain is driven by means of the pulley *p*, known as the *traversing pulley*, which is attached to a journal *j* that passes through a sleeve formed in one piece with the head of the shell. Attached to this journal is a bevel gear *e* that drives a gear *d* driving another gear, to which is attached the driving sprocket *c*, around which the chain passes. At the other end of the shell is a flange binder pulley *r* around which the chain passes and which may be adjusted by means of an adjusting screw *n*, in order to take up the slack of the chain when it stretches. A rotary

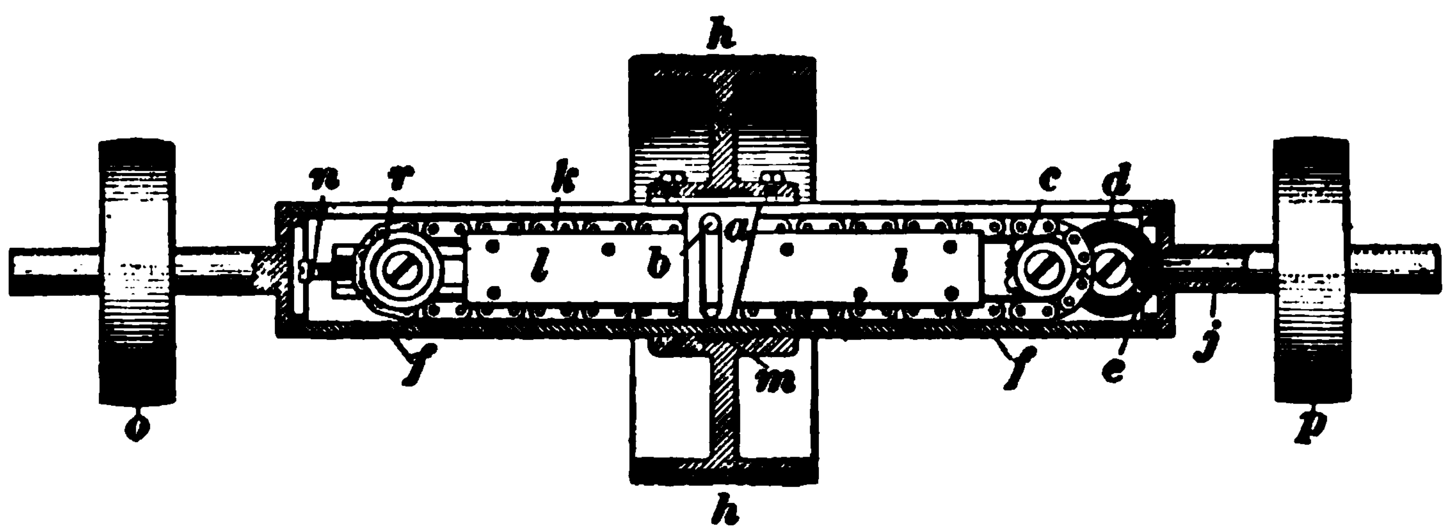


FIG. 9

motion is imparted to the grinding wheel by means of the pulley *o*, which is attached to a shaft forged in a solid piece with the other head of the shell. This pulley imparts motion to the shell; and as the T piece projects through the slot in the shell, the motion is also imparted to the grinding wheel. A steel plate *l* guides the chain.

The *grinding wheel* is an iron pulley covered with twine and afterwards having coarse emery glued on it. Special emery fillet is sometimes used for covering grinding wheels and rolls. Covering emery rolls should not be attempted in the mill unless emery fillet is employed, as the work must be perfect and the roll true; otherwise, the grinding will be imperfect. The emery should always be coarse, in order to allow the particles to project into the clothing and to grind the

sides of the teeth as well as the top. Grinding wheels are made up to 13 inches in diameter and the larger the wheel within reasonable limits, the better work it will do. In order that the grinding wheel may slide easily on the shell, a chamber *m* is cut around the inside of its hub and a felt washer inserted; this being saturated with oil lubricates the shell as the grinding wheel slides back and forth. The shells for traverse grinders are made 4 or 5 inches in diameter. The 5-inch shell is to be preferred, since the greater the diameter, the less is the tendency of the shell to spring and consequently to make the grinding uneven.

27. Speed.—The traversing pulley *p*, Figs. 8 and 9, should always be driven more slowly than the driving pulley as, both being driven in the same direction, there would be no traverse of the grinding wheel if the speeds of both pulleys were equal. The revolutions of the bevel gear *e* that drives the traverse chain is equal to the revolutions of the driving pulley *o* minus the revolutions of the traversing pulley *p*. In order to make the grinding wheel traverse faster, the speed of the traversing pulley is reduced.

The speed at which grinders are driven varies considerably with different carders, but the following table gives the average speed of the grinding wheel and the number of times that it traverses across the card per minute. The table is made for different widths of cards.

TABLE V

Width of Card or Traverse of Grinder Wheel Inches	Revolutions per Minute of Grinder Wheel	Number of Times Across the Card per Minute
36	375	15
40	365	14
48	340	12
60	300	10
72	275	8

28. Adjusting Device.—After a traverse grinder has been used for some time, the grinding wheel and shell become so worn that the grinding wheel is loose and perfect grinding is difficult to attain. In order to remedy this defect and to afford a method of easily adjusting the size of the hole in the hub of the grinding wheel to the diameter of the shell, the hole in the grinding wheel in the latest machines is bored tapered instead of straight. A tapered, split bushing with a chamber for the felt oiler is inserted into the tapered hole in the grinding wheel; a collar is then screwed on each side of the hub of the wheel up to the bushing. By loosening collar at the small end of the bushing and tightening the one at the large end, the bushing is pressed into the hub of the wheel and, being split and tapered, is contracted around the shell until a proper fit is obtained.

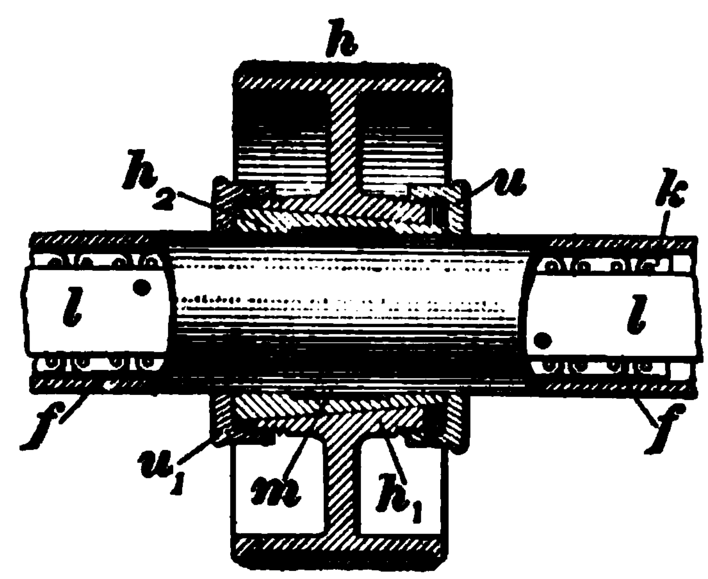


Fig. 10

This device is not shown in Fig. 9, being placed only on the latest models, but it is shown in Fig. 10; h_1 is the hub of the grinding wheel, which is bored tapered, while h_2 is the tapered bushing that fits into h_1 and is held in position and adjusted by means of the threaded collars u, u_1. To tighten the grinding wheel, thus giving less play on the shell, loosen collar u and tighten u_1; loosening u_1 and tightening u has the opposite effect.

29. Operation.—The method of grinding the main cylinder and doffer at the same time by means of the traverse grinder just described is as follows: Referring to Fig. 8, it will be seen that the journals of the shell are carried in adjustable bearings, which may be moved in two directions by means of screws provided with hand wheels, allowing the grinding roll to be set both to the main cylinder and also to the doffer. The doffer, however, is usually set

to the grinding wheel instead of the wheel being set to the doffer. The bearings of the traverse grinder are bolted to the fancy brackets when grinding the main cylinder and doffer, the fancy and last worker being removed and placed in a rack in order to allow room for the grinding wheel. Usually, however, the workers and smaller rolls of the card are being ground on the grinding frame (which will be dealt with later) while the main cylinder and doffer are being ground.

When grinding the main cylinder its direction of rotation is reversed, in order to grind against the backs of the teeth. When the card is driven with an open belt, the direction of rotation of the main cylinder may be reversed by crossing the belt, but if the card is driven by a cross-belt, the belt will have to be taken up by means of holes punched in it, and run open. Often an extra belt is provided for driving the cards while grinding cylinders. The doffer should run in its usual direction, but its speed should be increased by putting a pulley on its shaft and driving it from the main-cylinder shaft.

The grinder may be driven from pulleys fastened to the third stripper shaft of the card. A pulley may be placed on each end of the stripper shaft, one for driving the shell and another smaller one for the traversing motion of the grinder. The stripper may be driven from a belt directly from the flange on the main cylinder. Before placing the grinder on the fancy brackets, the doffer should be moved from the main cylinder about 2 inches. The grinder may then be set to the main cylinder until a whizzing sound, caused by the contact of the emery with the clothing, is heard. Each side should be carefully adjusted so that the wire will not be overground on one side. After the grinder has been adjusted to the main cylinder the doffer may be adjusted to the grinder, using the same precautions as before, in order to grind the doffer even.

The doffer should always have the preference over the cylinder and should always be sharper; however, the grinder should not press too hard on the wire or a hook will be formed on the under side. It is better to set the grinder light at first and after the grinding has been going on for an

hour set it down a little heavier. The grinding of the cylinder and doffer usually takes from 4 to 8 hours. The wire is tested at intervals to see if it is sharp enough, by means of the thumb, which is pressed against the point. It is also a good plan to examine the wire with a magnifying or pick glass to determine whether the point of the tooth is ground to the proper shape and also to be sure that the point is not turned over and the wire hooked.

It is always best when grinding to stop a little short of the sharpest point possible rather than to put a burr point on the wire. Smoothness should be sought more than sharpness. In case the wire becomes hooked, the defect may be remedied to a certain extent by *facing* the wire or by using a burnishing brush, which is a roll covered with straight clothing set loosely in the foundation. This roll is set to run into the clothing and removes the burr. Facing is a dangerous operation and often results in the ruin of the clothing. The operation consists of running the grinding roll against the points of the clothing and should be done very lightly, only allowing the grinder barely to touch; otherwise, the clothing will be damaged. It is best never to run a grinding roll in this manner.

The traverse of the grinding wheel should preferably be long enough to carry it clear of the clothing on each side. This prevents all possibility of the clothing being ground at the ends of the cylinders more than in the center, which sometimes happens when the motion of the grinding wheel is reversed before it has cleared the clothing, as it then remains in contact with the sides of the clothing for a longer time than with the other parts.

30. Some grinders instead of being driven by means of a chain have a traversing motion imparted to them by means of a reciprocating screw; that is, a screw provided with right-hand and left-hand threads that are joined at each end. In the groove, fits a fork, or traveler, having a stem through the slot in the outer shell in which the screw turns. By means of the stem the grinding wheel is not only rotated by

the shell, but a traversing motion is imparted to it by the screw. The fork changes from one thread to the other and reverses the motion of the grinding wheel at each side.

TRAVERSE GRINDING FRAMES

31. The workers, strippers, fancies, and tumblers are not ground in their positions, as are the main cylinder and doffer of the card, but are removed and taken to a machine called a **grinding frame.** This machine, shown in Fig. 11, consists of an iron frame on which is mounted, on suitable bearings, a traverse grinding wheel *h* identical with the one employed in grinding the cylinder and doffer. The grinding frame is arranged to grind two rolls at one time, one on each side of the traversing grinding wheel, the rolls being placed in V-shaped notches in the slides *c* that rest on the top of the frame. These slides are adjustable, by means of screws, to the grinding wheel, thus allowing the rolls being ground to be adjusted to the same. The screws are provided with hand wheels *d* for easily adjusting the rolls and also with check-nuts for locking them when once the rolls have been set. Pulleys, setscrewed to the shafts of the rolls to be ground, are driven by means of a belt from the bottom shaft of the grinding frame. The grinding wheel is also driven from the bottom shaft of the frame by two belts, one of which drives the traversing motion of the grinding wheel while the other imparts a rotating motion to it. When putting on the belts before grinding, care should be taken before the rolls are set up to the wheel to see that the directions of rotation are such that the grinding wheel will grind the backs of the teeth on each roll.

Referring to Fig. 11, it will be seen that an adjustable stand *f* also carries slides with V-shaped notches; this is for the purpose of grinding shorter rolls that do not have shafts long enough to rest in the bearings on each side of the machine. Inside of the frame of the grinder there is a small emery-covered roll *g* for grinding hand cards; this is driven from the main or bottom shaft.

Fig. 11

The grinding of the smaller rolls of the card takes 3 to 4 hours. Great care should be taken when grinding strippers not to injure the wire because, owing to the small diameter of the stripper, the wire stands more open on it than on the larger rolls. The workers should have the most grinding of the smaller rolls of the card, as they need a sharp point for taking the wool from the main cylinder as well as for the actual carding.

The fancy should not require much grinding, as its friction with the main cylinder should keep it in good condition. Many carders do not grind the fancy at all, claiming that as the fancy does not engage with the wool perfect smoothness is better than sharpness. The point produced on any roll by wear is always smoother than that obtained by grinding. If the fancy is ground it should be ground very lightly and only for a short time, so as not to jam or disarrange the long teeth of the roll. After grinding, it is a good plan to allow the fancy to run into the cylinder of the card for about ½ hour, being set up hard at first and afterwards being moved off to its normal position. This will take off any roughness left by the emery. When grinding the tumbler perfect smoothness is desired rather than extreme sharpness.

32. Grinding Metallic Rolls.—Occasionally the burr cylinder of the first breaker card or the metallic feed-rolls need grinding and sometimes the burr cylinders of the burr picker are brought to the card room for grinding. The grinding of these rolls is a difficult task and should never be attempted until the roll is considerably worn, as at best they can only be improved and not rendered as good as new. Metallic burr rolls may be ground on the traverse grinding frame, but the *solid emery* or *carborundum* wheel should be used instead of the iron grinding wheel covered with emery. The grinding frames are supplied with solid wheels if so desired. When grinding metallic rolls the grinding wheel should always revolve against the point of the teeth. This is the opposite way from which the rolls covered with card clothing revolve, but it is necessary in order to prevent the

metallic wire from becoming hooked. The burr cylinder should be made to revolve very slowly, say not more than 10 turns per minute, and the grinder pressed very lightly against it. The grinding being very light, it takes more time, and 2 days are sometimes spent in grinding a single roll. Sometimes a file is fixed in the turning post of the grinder and allowed to bear on the surface of the roll. The roll is then revolved toward the file at the rate of from 250 to 300 revolutions per minute. If burr cylinders are worn very badly, they are placed in a lathe and turned down.

When grinding any metallic roll great care should be taken not to heat it, which is very apt to be done and may affect the trueness of the cylinder. Small rolls, like feed-rolls, are very difficult to sharpen and more satisfactory results can be obtained by filing them by hand.

After the burr cylinder is ground sufficiently to feel sharp to the hand, although it cannot be made to feel as sharp as card clothing, means must be taken for smoothing it up. The grinding always leaves a metallic roll rough and the teeth more or less burred, or hooked. One way to smooth a metallic roll after grinding is to reverse its direction of rotation and hold the end of a soft pine board against it until notches are worn by the teeth. The end of the board may be moistened with oil and sprinkled with powdered emery, which will smooth the teeth and remove any rough edges, leaving the roll smooth and in good condition.

ROLLER GRINDING FRAME

33. The grinding frame shown in Fig. 11 contains a narrow traversing grinding wheel, but Fig. 12 shows a grinding frame known as the **roller grinder**, which is preferred by some carders. This grinder is identical with the traverse-wheel grinding frame with the exception of the wheel, or roll, *h* for grinding, which extends entirely across the frame, grinding the entire surface of the worker or other roll at once. Rolls can be ground in less time with a roller grinder, but are more liable to be ground in stripes or

Fig 12

unevenly. To prevent this the roller grinder has a slight traverse of about 2 inches. This is accomplished by giving the roller a reciprocating motion by means of the device shown on the right-hand side of the grinding-roll shaft. This consists of a worm on the shaft, which meshes with a worm-gear, both being contained in the casing h_1, Fig. 12. On the side of the worm-gear is a crankpin that is connected to the stationary bearing of the grinding-roll shaft by means of rod h_2. When the grinding-roll shaft revolves, the worm-gear is turned and the crankpin, working against the arm attached to the stationary bearing, moves the whole casing, and also the grinding roll, by means of collars on the shaft. A roller grinder is also made for grinding cylinders and doffers.

TRUING WOODEN CYLINDERS

34. Often when wooden rolls are used in a card it will be found that they are not true when the card is being set or when the roll is being ground. In this case the rolls should not be evened up by grinding, as this will make some of the teeth shorter than others and make good carding difficult. The only remedy is to take off the clothing and turn down the roll. This is done on a grinding frame, except in the case of the main cylinder, which is trued by fastening the turning lathe to the frame of the card, the doffer being removed. After the clothing has been taken off from the roll that is to be trued, the roll is placed in the grinding frame. In the case of large rolls, as for instance a doffer, it is sometimes necessary to remove the grinding wheel in order to make room.

It will be noticed, Figs. 11 and 12, that the turning lathe is fastened to the front of the grinding frame and consists of a rest i on which there is a movable slide j carrying a tool post k, in which the turning knife is fastened. The slide is controlled by a screw l running the width of the frame, which is either turned by hand by means of a handle or preferably driven by means of a belt and two three-step pulleys, one on the screw shaft and the other on the bottom shaft of the

grinding frame, as seen at the right of the frame. A small handle j_1, under the slide, allows it to be disengaged from the screw after the latter has been moved entirely across the width of the roll that is being trued. The slide is then moved back by hand and the handle underneath turned in, which allows the screw to act and the slide to make another traverse.

The whole turning lathe may be adjusted to the roll that is being trued by means of hand wheels *m* on each side of the machine, which operate screws provided with check-nuts for fastening the lathe in any desired position. Small adjustments of the turning knife may be made by means of a crank that operates the tool post. Care should be taken to have the rest perfectly parallel with the shaft of the roll to be trued. The turning knife passes through a slot in the turning post and is so arranged that it may be set and securely fastened at any angle. When turning, or truing, the point of contact of the turning knife with the cylinder should be on a level with or slightly above the axis of the latter.

When truing the main cylinder of the card it often becomes necessary to place blocks under the turning lathe in order to raise it high enough. The doffer being removed, the turning lathe is placed in its position resting on the end of the card frame. If it is not desired to place blocks under the lathe, the turning knife should be set so as to come in contact with the cylinder at the proper angle.

It is better to take off several small, or thin, shavings from the cylinder rather than to attempt too thick a shaving. Before putting the knife to the cylinder, the latter should be scraped by holding on it the edge of a piece of board or an old piece of sheet-iron or steel with a straight edge; this removes any grease or dirt that may be on it which would dull the knife.

In order to make a smooth surface, the turning knife must be sharp and the cylinder should revolve against its edge. When removing sheets from a cylinder before truing it, care should be taken, if the heads of the tacks are broken off, not to leave the latter protruding in the wood, where they will come

in contact with and ruin the turning knife. It is better to drive the slide that carries the knife with a belt rather than to attempt to turn it by hand, as more uniform results will then be obtained. If it is desired to operate the slide by hand, it is best to disengage it from the screw entirely and move it across the face of the cylinder with a firm, uniform pressure. The turning lathe should always be in line with the axis of the main cylinder. If the latter is level, as it should be, the turning lathe may be leveled also; but otherwise it is a good plan to sight the shaft of the cylinder over the lathe rest.

After the cylinder has been trued and its surface made to run perfectly, a sheet of sandpaper tacked on a block of wood may be lightly passed over the surface finally to smooth it before replacing the clothing. If there are small knot holes in the cylinder they must be filled with putty, slightly warmed beeswax, or a wooden plug, before the clothing is put on; otherwise, the teeth over them will be pushed through the foundation of the clothing and be lower than the rest.

In turning the smaller rolls of the card, the same rules apply as with the main cylinder, except that they are trued in the grinding frame. Iron cylinders and doffers never have to be trued if properly used, but if sprung through any accident, they should be turned down in the machine shop.

CLOTHING CARDS

COVERING WITH SHEET CLOTHING

35. Whenever old clothing is replaced with new, or after cylinders have been trued, there arises the necessity of recovering the cards, this may be done with one of three coverings—sheets, fillet, or rings. The **sheet clothing,** as has been previously stated, consists of sheets 5 inches wide and as long as the width of the card. They are used on the main cylinders of the first and second breakers, and in order to prevent their blistering, or raising, in the center, they

should be applied with considerable tension and be securely fastened in place with long tacks, 12-ounce tacks being suitable for this purpose. Tacks made without any web on the under side of the head, which would be liable to cut the foundation, are provided for attaching card clothing to the cards.

The cylinder should first be marked off with a pencil so that each sheet will be placed in the proper position and parallel to the axis of the main cylinder. This marking is usually done after the cylinder is turned down and with the turning lathe in position. With the cylinder turning, a mark is first made with a pencil $\frac{3}{4}$ inch from each edge. Then the circumference of the cylinder is divided on one of these lines, with a pair of dividers, into as many parts as there are sheets. If the main cylinder is 48 inches in diameter it is customary to apply twenty-four sheets, a certain amount of space being necessary between the sheets for tacking; this means that twenty-four equal divisions will be made around the cylinder. Then using the turning rest, which is parallel to the axis of the main cylinder, as a rest, a line is marked across the card at each of the points spaced off with the dividers. The turning lathe is then removed from the card and the sheets of clothing applied. The tacks should first be stuck into each sheet about $\frac{7}{8}$ inch apart and $\frac{1}{4}$ inch from the wire. The upper edge of the sheet is then placed on one of the lines drawn across the main cylinder and the tacks driven in. A clamp, Fig. 13, is then attached to the lower edge of the sheet and a strap passed through the link of the clamp and attached to a ratchet, by which the sheet of clothing can be stretched. The ends of the sheets should always be stretched first and firmly tacked, after which the middle portion of the sheet may be stretched and tacked.

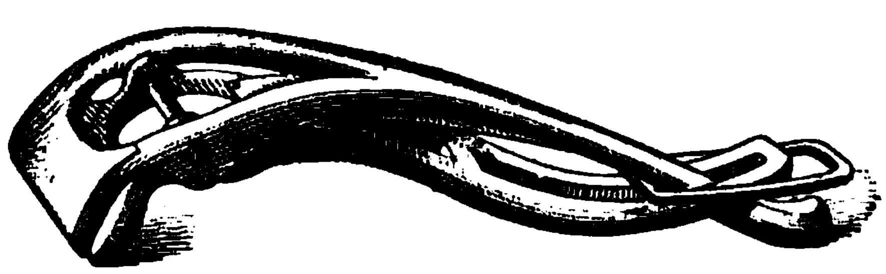


FIG. 13

While the tension is being applied to the sheet, the main cylinder must be prevented from turning. This may be

accomplished by means of a bar of iron propped against the bolts on the inside of the cylinder and resting on the floor. After the first sheet is tacked on, the lower edge should be trimmed to the pencil line and the operation repeated.

When stretching the last sheet, it will be necessary to place a block of wood in the space between the sheets on the first and second sheets tacked on for the clamp to rest on so that it will not injure the clothing. After all the sheets are on, the ends of each sheet should be drawn out and a single tack put in each. If the card clothing is sufficiently stretched and well tacked it will not blister. Iron cylinders have parallel rows of holes drilled in their surfaces and tapered, hardwood plugs driven into the holes. The tacks are driven into these plugs when the clothing is applied.

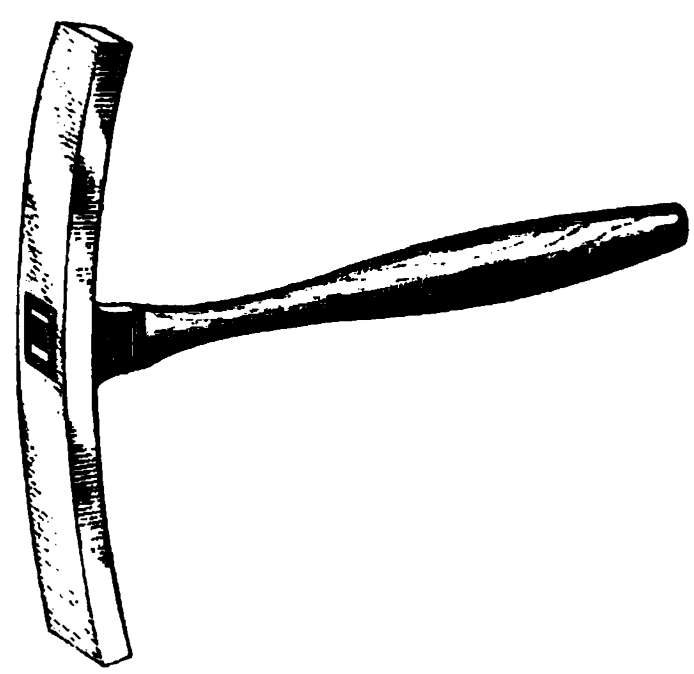


FIG. 14

The hammer used for driving the tacks when sheet clothing is being applied is of a peculiar shape, as shown in Fig. 14; the head is 8 or 10 inches long and the face of the hammer $\frac{1}{4}$ in. × 1 in. This shape is adapted for driving the tacks without jamming the card clothing.

COVERING WITH FILLET

36. Fillet Winding Frame.—The rolls of the card that are not covered with sheet clothing, metallic wire, or rings are covered with fillet, which is applied by various means, the object being to wind the fillet with sufficient tension to prevent its becoming slack.

Fig. 15 shows a machine for doing this. The desired length of fillet for any given roll is found (as will be explained later) and one end tacked to the large drum *f*, around which it is wound; the other end of the fillet is then

tapered and tacked to the roll *e*, which is to be covered, and which is turned by means of the crank-handle *d* and gears *c*, *b*.

FIG. 15

The desired tension is obtained by means of an adjustable weight *w* placed on a lever, to which a strap passing around

a flange on the drum *f* is attached. By moving the weight, any amount of friction may be placed on the drum and,

consequently, any amount of tension on the fillet that is desired may be obtained. When the end of the roll is reached, the fillet should be carefully secured and then trimmed off flush with the end of the roll. The taper at each end is necessitated by the fact that the fillet is wound on spirally and the taper must therefore coincide with the pitch of the spiral.

Fig. 17

37. Fig. 16 shows a fillet winding frame similar to the one described except that it is equipped with a patent drum for regulating the tension of the fillet as it is placed on the cylinder. An enlarged view of it is shown in Fig. 17, where it will be seen that it consists of a carriage *a* that slides on a bed *b*. Sufficient motion is imparted to the carriage by means of a screw *c* to guide the spirals of fillet close up to each other. The fillet when being wound is usually placed in a basket, from which the end is taken and passed through

the trough *d* to what is known as the *cone drum e*, around which it is wrapped three times. The fillet emerges over the roller *f* and is guided on the roll to be wound by the rod *g*.

The tension is obtained in the following manner: The drum *e*, which revolves as the fillet passes over it, is made in three sections—the first $6\frac{1}{2}$ inches, the second 7 inches, and the third $7\frac{1}{2}$ inches in diameter. The part with the largest diameter is covered with leather so that this portion of the drum and the fillet revolve together; and as it requires a greater length of fillet to cover this surface than it does to cover either of the smaller sections, the fillet is drawn over these at a greater speed than that at which their surfaces revolve. The friction between the fillet and the drum produces the tension on the former, the amount of which may be regulated by the brake *h* on the drum shaft and also by a thumbscrew *j* that presses the die *k* down on the fillet, which is drawn over a spring cushion.

About 200 pounds tension may be obtained by means of the brake *h* alone, the rest being obtained by means of the thumbscrew *j*. The fillet must always be passed through the trough so that the teeth will point in the opposite direction to its motion; otherwise, they will be injured. For main cylinders wound with 2-inch fillet a tension of 275 pounds is about right; smaller rolls require less tension as does also narrower fillet. Doffers may have fillet applied with about 175 pounds tension, while 125 pounds is sufficient for workers. The amount of tension with which the fillet is being wound in this machine is indicated by a finger *l* on the dial f_3. This is accomplished by arranging the roll *f* to press against a strong coil spring f_2, connection being made with a rack f_1 and pinion l_1 so that the motion of the roll when acted on by the tension of the fillet is communicated to the finger and indicated on the dial.

The frame shown in Fig. 16 is also used for truing wooden rolls, in which case the fillet winding device is removed and a turning lathe substituted. In this case the frame is driven by a belt, but when winding fillet, motion is imparted to the

roll to be wound and to the winding device by means of the crank *m*.

In using this machine it is essential that for each revolution of the roll *n* the carriage shall move along the bed a distance corresponding to the width of the fillet. This is sometimes accomplished by gearing the screw that imparts the traverse motion to the carriage from the roll that is being covered, the train of gears being so arranged that 1 tooth of the change gear moves the carriage $\frac{1}{32}$ inch to each revolution of the roll. From this it will be seen that $1\frac{1}{2}$-inch fillet will require a 48-tooth gear and 2-inch fillet a 64-tooth gear. In actual practice, however, a 49-tooth gear is used for $1\frac{1}{2}$-inch and a 66-tooth gear for 2-inch fillet, since the fillet is wider than the nominal width and measures $1\frac{17}{32}$ inches and $2\frac{1}{16}$ inches, respectively.

After large rolls are covered with fillet they should be allowed to stand for 3 or 4 hours in order that the fillet may become adjusted and then it should be tacked crosswise of the cylinder. When covering with card clothing, if the roll is not reversible end for end, care must be taken to have the teeth of the clothing pointing in the right direction. As a rule, the workers, strippers, tumblers, and fancies are covered with $1\frac{1}{2}$-inch fillet, while the doffer is clothed with 2-inch fillet, as is also the finisher cylinder when it is clothed with fillet.

Before winding on the fillet some carders paint the surface of the cylinder or roll, but this is not done so much at the present day. The usual custom is to brush the cylinder with linseed oil just before the fillet is wound on. This prevents the backs of the teeth from rusting and also prevents cracks from opening in the cylinders. Iron cylinders, of course, do not need this treatment.

38. The following rule is used to find the length of filleting required to cover a given roll:

Rule.—*Multiply the diameter of the roll by its length, in inches, and by 3.1416 and divide by the width of the filleting multiplied by 12 to reduce the answer to feet.*

A little allowance must be made for tapering the ends of the fillet at the start and finish and also to leave enough to keep the tension when finally tacking the clothing to the rolls.

EXAMPLE 1.—What length of 2-inch filleting is required on a 48-inch card to cover a 24-inch doffer?

SOLUTION.— $\frac{24 \text{ in.} \times 48 \text{ in.} \times 3.1416}{2 \text{ in.} \times 12 \text{ in.}} = 150.796$ ft. Ans.

EXAMPLE 2.—What length of $1\frac{1}{2}$-inch filleting is required to cover a 10-inch fancy on a 60-inch card?

SOLUTION.— $\frac{10 \text{ in.} \times 60 \text{ in.} \times 3.1416}{1.5 \text{ in.} \times 12 \text{ in.}} = 104.72$ ft. Ans.

COVERING RING DOFFERS

39. Many carders have difficulty in clothing ring doffers, the rings being made endless and of a slightly smaller diameter than the doffer in order to fit it tightly. The following method of application, however, will be found to accomplish the purpose and not to injure the rings: The doffer should be taken out of the card and placed on end on a box, its shaft passing through a hole bored in the latter. To help in getting the rings on, a wooden cone may be made about 6 inches long, with its lower end of the same diameter as the doffer. Through its center a hole is made, which allows it to be placed on the doffer shaft. The rings may now be placed over the cone and pushed down about an inch over the doffer. A square board 3 or 4 inches wider than the diameter of the doffer should be obtained and a round hole slightly larger than the diameter of the doffer cut into it. This can be slipped over the doffer and the rings readily forced into place without bruising the leather by pounding. After all the rings are on the doffer it may be taken to the grinder and the rings, which are at varying distances apart, easily adjusted by means of a screwdriver or small stick. With the doffer revolving toward the operator but against the back of the teeth, the screwdriver should be pressed against the side of the leather part of the ring, which may thus be slid in any desired direction.

Before doing this, however, a gauge should be made for spacing the rings in order that the divisions between them may be made equal. This gauge consists of a stick as long as the width of the card and marked with as many divisions as there are rings, the latter to be spaced equally over a distance equal to the width of the clothing on the main cylinder. The waste-end ring, which is wider than the others, should be placed on the end of the top doffer farthest from the stripper belt and on the end of the bottom doffer nearest the stripper belt. Some carders place the top waste-end ring on the side of the card on which the longer side of the Apperly feed is.

The method of marking off a gauge stick for a 48-inch card with two waste ends and 48 rings on a double-doffer card is as follows: First the waste-end rings should be made $1\frac{1}{2}$ inches wide. This leaves 45 inches (48 inches − 3 inches) in which to place 48 rings. If the rings on the top and bottom doffers were all the same size, they would then be $\frac{45}{48}$ or $\frac{15}{16}$ inch wide, but the top rings must be narrower; therefore, the gauge stick must be marked so as to space twenty-four $\frac{14}{16}$-inch rings 1 inch apart on the top doffer, while the bottom doffer will have twenty-four 1-inch rings $\frac{14}{16}$ inch apart.

When the gauge is made for the right number of rings equally spaced, the doffer should be fastened with collars in the grinder so that it will have no lateral motion, or play, and the gauge placed in front of it about $\frac{1}{4}$ inch from the wire. The rings may now be moved with the screwdriver until they coincide with the divisions marked on the gauge. The bottom doffer is treated in the same manner and when both doffers are spaced, the rings of the top doffer should just fit into the spaces of the bottom doffer and the ends of the doffers should be flush.

40. Strips of leather, as free from grease and dirt as possible, are prepared as wide as the space between the leather part of the rings and glued or tacked in with the ends butting together. Filleting with the wires removed is

frequently used for this purpose. These strips should not be cut too wide or the rings will be forced from their positions; but, on the other hand, they should fit snugly so that the rings will be held firmly in position when the card is in operation.

Another method of securing the rings that is sometimes used is as follows: Having adjusted the rings in their correct positions, a cop of cotton yarn should be procured and with the doffer in the grinding frame and the teeth of the rings revolving against the point, the thread should be touched to the outside ring, to which it will instantly cling. The thread is then guided neatly back and forth between the rings, one layer of cotton being wound over another until the same thickness as the leather foundation of the ring is obtained; then the thread is quickly crossed over to the next space, and so on continuously to the end. When finished, the doffer is stopped and with a small brush and a thin glue solution the cotton is saturated, the crossings from one space to another first being cut and the ends of the cotton thread tied together. The grinding may be commenced at once and the packing will dry as the grinding proceeds. This makes a solid, compact filling with no danger of the rings becoming displaced. If desired, strips of leather may be tacked over the cotton filling, just touching the wires of the rings.

CARDING SURFACE

41. The following rule is used to find the number of square feet of carding surface on a cylinder covered with sheet clothing:

Rule.—*Multiply the length of the sheets (width of card) by the width of the sheets (5 inches) and by the total number of sheets on the cylinder and divide the product by the number of square inches in 1 square foot (144).*

EXAMPLE.—On the main cylinder of a 48-inch first breaker card there are 24 sheets of card clothing; how many square feet of carding surface has the cylinder?

SOLUTION.— $\frac{48 \text{ in.} \times 5 \text{ in.} \times 24}{144} = 40$ sq. ft. Ans.

42. To find the number of square feet of carding surface on a cylinder or roll covered with filleting:

Rule.—*Multiply the diameter of the cylinder, in inches, by 3.1416 and by its length, in inches, and divide the product thus obtained by the number of square inches in 1 square foot (144).*

NOTE.—To find the exact surface area of a given cylinder at the points of the clothing, add ¾ inch to its diameter.

EXAMPLE.—How many square feet of carding surface on a 7-inch worker, the card being 48 inches wide?

SOLUTION.—

$$\frac{7\tfrac{3}{4} \text{ in.} \times 3.1416 \times 48 \text{ in.}}{144} = 8.115 \text{ sq. ft.} \quad \text{Ans.}$$

43. The following tables show the amount of clothing required for a set of 48-inch cards, the finisher main cylinder being covered with filleting. The reference to angular wire refers to the angular, or diamond-point, wire with which the lickers-in and feed-rolls of the second breaker and finisher cards are covered, this wire being stronger and coarser than the ordinary card clothing wire. Lickers-in may be garnetted with licker-in wire.

TABLE VI

FIRST BREAKER

No.	Cylinders	Dimensions Inches	Length Feet	Width Inches	Square Feet
24	Sheets (main cyl.)	5 × 48			40.00
6	Workers	7 × 48	61	1½	43.98
6	Strippers	3 × 48	27	1½	18.84
1	Doffer	24 × 48	156	2	25.13
1	Fancy	10 × 48	87	1½	10.47
1	Tumbler	9 × 48	78	1½	9.42
1	Burr cylinder	7 × 48	Metallic		7.33
2	Feed-rolls	2 × 48	Metallic		4.18
					159.35

TABLE VII

SECOND BREAKER

No.	Cylinders	Dimensions Inches	Length Feet	Width Inches	Square Feet
24	Sheets (main cyl.)	5 × 48			40.00
6	Workers	7 × 48	61	1½	43.98
6	Strippers	3 × 48	27	1½	18.84
1	Doffer	24 × 48	156	2	25.13
1	Fancy	10 × 48	87	1½	10.47
1	Tumbler	9 × 48	78	1½	9.42
1	Licker-in	5½ × 48	48	1½ angular	5.75
1	Licker-in fancy	3 × 48	27	1½	3.14
1	Feed-roll stripper	1¾ × 48	24	1 angular	1.83
2	Feed-rolls	1¾ × 48	24	1 angular	3.66
					162.22

TABLE VIII

FINISHER

No.	Cylinders	Dimensions Inches	Length Feet	Width Inches	Square Feet
1	Cylinder	48 × 48	312	2	50.26
5	Workers	7 × 48	61	1½	36.65
5	Strippers	3 × 48	27	1½	15.70
1	Fancy	10 × 48	87	1½	10.47
1	Tumbler	9 × 48	78	1½	9.42
1	Licker-in	5½ × 48	48	1½ angular	5.75
1	Licker-in fancy	3 × 48	27	1½	3.14
1	Feed-roll stripper	1¾ × 48	24	1 angular	1.83
2	Feed-rolls	1¾ × 48	24	1 angular	3.66
48	Rings (doffers)	12 × 48			12.56
					149.44

The lengths given in these tables for fillet clothing are long enough to allow for tapering the fillet on each end of the cylinder. The total carding surface of the entire set of cards is approximately 471 square feet; this is the surface of the rolls before they are covered. The surface of the teeth of the card clothing itself would be slightly in excess of this.

POINTS IN MANAGEMENT

44. In the management of card rooms many points must be watched, but the following results should always be attained: (1) The production of good work; (2) as large a production as is consistent with the quality of work required; (3) economy in avoiding unnecessary waste and keeping down the expense of wages, power, supplies, etc.; (4) the maintenance of the machinery in good condition.

With reference to the first point, it may be said that this is judged by the appearance of the roving and by the resulting yarn. If the rovings are round and full, free from *twits* and imperfections, and of the right weight, the carder may feel satisfied that any imperfection of the resulting yarn is not due to the carding. A **twit** is a thin place in the roving, or yarn, that looks as though the roving were partly broken. Where twits occur in the roving, bunches and thick places are also apt to occur. If the roving is twitty, the yarn will also be full of thin places. Twitty roving causes much trouble in card rooms; it is produced in many ways. Sometimes the twits are caused as far back as the scouring, since if the wool is scoured with too hot liquor the grease seems to be driven into the fiber, rendering it stiff and wiry. Wool rendered harsh in the drying will also make twitty roving, unless carefully oiled and carded. Sometimes the clothing on the finisher-card cylinder grows slack and blisters through usage; this is a cause of twits that is only remedied by taking the clothing from the cylinder, recovering it, and afterwards grinding to a true surface. A poorly working licker-in on the finisher is also apt to cause twits; the licker-in should always take the wool evenly in small bunches and

not in large flakes or uneven bunches. Twitty roving is often caused by trying to spin fine yarn out of wool that is only fit for spinning coarse yarn. Sometimes a poorly working fancy will cause twits, especially if it is inclined to *choke* with wool, when it is often called a *lapping fancy*. Any defect in the doffer rings of the finisher doffers is sure to cause a defect in roving. These rings should be carefully attended to and kept in good condition; they should always be smooth and have a point that is sharper than the cylinder of the finisher. If the wipe roll, which strips the ribbons of carded wool from the rings, is driven too fast or if not set properly with regard to the rings, twitty roving is liable to result. Twits are also sometimes caused by too much draft between the aprons of the condenser and sometimes by poor or dirty aprons. Sometimes the rovings are not rubbed solid enough and so are liable to be weak in places. Twits are often caused by too high speed of the cards, especially of the ring doffers. If one fiber receives more oil than another, that fiber has a different action; and when one part of the batch of wool is over-oiled and another part is not sufficiently lubricated, twitty and uneven roving will often result.

Great care should be taken to bring the stock from the first breaker in good condition, as on the character of the carding done by the first breaker the resulting roving will largely depend. The side drawing from the first breaker card should be frequently examined for neps and vegetable matter. The sliver should be round and full from the first and second breakers and the rovings from the finisher card should be round and perfect, without having been rubbed too much. All little points that tend to deteriorate the quality of the work should be carefully attended to and the cards stripped when necessary; that is, when they become so filled with dirt as to clog the clothing and prevent the wire from acting freely on the stock as it passes through the card.

The economizing of production can be obtained by limiting as much as possible the time allowed for stripping, grinding, or setting the cards and also by not allowing the

rest of the set to be stopped any longer than is necessary while stripping or grinding one card. The production may be increased by speeding up the whole card or by increasing the speed of the doffer and the feed-rolls by changing the small gear that drives the large gear on the doffer shaft. Cards should never be speeded so fast as to make a large percentage of flyings, as these not only increase the amount of waste, but settle on the card and make it more difficult to clean, besides having a tendency to work into the bearings and around the shaft, collecting in lumps that are sometimes caught and carried into the card, rendering the roving uneven. Too much stock should not be forced through the card by speeding up the doffer, nor should the sliver be made too heavy. The quality of the work in woolen carding should rarely be sacrificed for production.

As a rule, two men or boys will care for from four to six sets of cards with a creel feed at the second breaker and an Apperly feed for the finisher card. Two men will strip from eight to twelve sets of cards. The labor cost of a card room varies according to the price of labor in the locality in which the mill is located, the class of work, and other conditions.

As little waste as possible should be made and all soft and clean waste should be run through the cards again. A good deal of the waste around the card may be dusted, run through the picker, and then worked over. Greasy waste should not be allowed to accumulate in piles or in bins, and water should never be put on greasy waste. Under these conditions there is great danger of spontaneous combustion and a serious fire.

The care of machinery requires that the cards shall be frequently cleaned and oiled. Cards should be wiped down with a piece of waste every night, the flyings removed and also the waste on the floor gathered up. Every week the cards should be thoroughly cleaned and the card room swept. The cards should be carefully cleaned after every stripping, and all dirt and waste removed from the bearings. After cards have been ground they should be cleaned and the wire brushed out with a strong bristle brush.

Machinery, in order to be kept in the best condition, requires frequent oiling. All fast-running parts of the card, such as the strippers, main-cylinder, fancy, tumbler, and licker-in bearings should be oiled twice a day. The workers do not need to be oiled oftener than once in 2 or 3 days and sometimes not more than once in a week. The main-cylinder and fancy bearings should be packed with tallow, having a small hole in the center so that it will allow the oil to run directly on the shafts and provide a reserve of lubrication that will melt in case of a hot bearing. If tallow cannot be obtained, small pieces of waste should be placed in the bearings and soaked with heavy oil. The doffer-comb driving mechanism is run in oil and should be examined once in 2 weeks to see if there is sufficient oil in the reservoir, or casing.

All belts on the card should be examined once a week, especially the stripper belt, and all broken or worn lacings should be replaced. The belts should be cleaned every time the cards are stripped and, when dry, they should be oiled with castor oil. When the parts of the card are disturbed in any way, they should be carefully gone over again in order to detect any variation in the setting.

ELECTRICITY IN THE CARD ROOM

45. Any animal fiber, especially wool or silk, is liable to become charged with electricity, owing to friction combined with a dry state of the fiber and of the atmosphere. The place where the most difficulty with electricity is experienced in woolen carding is at the condenser, where the rubbing action of the aprons, or rolls, tends to charge the rovings with static or frictional electricity, which causes them to cling to the aprons and to the iron parts of the card frame and spool stand, thus becoming broken and winding around the rubs. When a roving breaks and is not immediately replaced, a blank space is left in the spool, making it imperfect. Sometimes when very dry or harsh stock is being carded, it becomes almost impossible to run the cards, owing

to the electricity, which is more troublesome in dry weather than in damp and in winter than in summer.

The card room should always be fitted with a humidifying plant in order to keep the air moist and thus reduce the electric charges as much as possible, but even then there is often difficulty with the rovings. The longer the throw, or the traverse, of the condenser aprons and the closer together they are set, the more difficulty there is; the electrification may often be reduced by setting the aprons farther apart and decreasing the traverse, only allowing enough rubbing action to condense the rovings into a round thread.

A remedy that is sometimes used with good results for the prevention of electric charges is soap, which, when added to the emulsion when the wool is being oiled, seems to render the wool soft and less liable to become electrified. About 2 pounds of soap to 100 pounds of wool is generally sufficient to prevent electrification and also to render the stock moist and silky in feeling, enabling the yarn to be spun into a round, lofty thread. Alum has been found to reduce the liability to electrical effects and is usually dissolved in the water used for the emulsion for oiling in about the proportion of ½ pound of alum to 100 pounds of stock.

The use of steam is sometimes resorted to in order to prevent electric charges from being produced, although steam is expensive to use for this purpose. The method is to run a steam pipe under the floor of the card room on a line with the condensers. Holes are bored at the end of each condenser and the pipe under the floor tapped with a ½-inch pipe, which should extend across the condenser 2½ inches below the lower rovings and plumb with the rear of the rub aprons. This pipe should be perforated with small holes 2 or 3 inches apart and should have a valve attached so that the steam may be turned on or off as desired. There will be no trouble with electrification if the steam is turned on before starting the cards. No more steam should be turned on than is absolutely necessary, or the aprons will stretch or become otherwise injured; and it should be shut off the moment the finisher card is stopped. It should not be

used unless the presence of electric charges is very evident as, if too much is used, the wire of the finisher card may become rusted.

WEIGHT OF ROVING

46. In order that a woolen yarn may have a definite size, or **run,** that is, a certain number of yards per pound, it is necessary that the roving, or roping, from the cards shall be of a given, uniform weight. It is, therefore, one of the duties of the carder to make the rovings of such weight that they may be spun into the required run of yarn with a reasonable draft in the spinning.

The draft that can be given on the mule depends on the quality of wool used and the size of the yarn being spun. If the wool is of good quality and is not spun too fine, a half draft in the mule is reasonable; that is, if the draw of the carriage is 72 inches, then 36 inches of roving will be let out before the delivery rolls of the mule stop. If a low grade of stock is being spun, it may be necessary to let out 40 or more inches of roving before stopping the delivery rolls. If the mules are running on half draft, that is, letting out 36 inches of roving and drafting it into 72 inches of yarn, the roving must be brought from the card just twice the weight of the required yarn.

It is not customary actually to figure the weight of the roving by the amount of wool fed to the card, as the weight of stock fed is an unknown quantity; though the Bramwell feed supplies the wool to the card uniformly by weight, this weight is not usually known or taken into account. The point is to bring from the first breaker a sliver that will allow a suitable gear on the second breaker to give the required weight of the roving from the finisher. For instance, if the card is taking off 48 ends, the side drawing from the first breaker should weigh from 200 to 220 grains per yard if it is desired to make 4-run yarn. For a 40-inch card, carding for 4-run yarn and taking off 40 ends from the finisher, the side drawing from the first breaker may weigh from 180 to 190 grains per yard. These

weights give sufficient leeway for changing the gear on the doffer shaft of the second breaker until the rovings from the finisher are of the right size.

47. Finding Required Size of Roving.—The size of the roving, as has been previously explained, depends on the number of yarn to be spun and on the draft of the roving in spinning. The latter depends on the character of the stock and also on how near to the limit of its capabilities it is being spun; low stock will stand less draft than sound wool with good spinning properties. The size of the roving necessary to spin a given yarn is to the amount of roving let out by the delivery rolls of the mule as the number of yarn spun is to the draw of the carriage; therefore, the following rule is necessary to find the size of roving that should be made on the card for a given size, or run, of yarn, the draft in the mule in spinning being known:

Rule.—*Multiply the length of roving, expressed in inches, delivered by the rolls on the mule by the size, or run, of the yarn to be spun and divide by the draw of the carriage, in inches* (72). *The answer will be the size of roving required to spin the run desired with the draft given.*

EXAMPLE.—Suppose that it is desired to spin $5\frac{1}{2}$-run yarn and that the stock will allow 36 inches delivery of roving to be drawn out to 72 inches of yarn of the desired size. Of what weight should the roving be brought from the card?

SOLUTION.— $\frac{36 \text{ in.} \times 5.5 \text{ run}}{72 \text{ in.}} = 2\frac{3}{4}$-run. Ans.

48. Changing Size of Roving.—The carder, having found the required run of the roving, must now take steps to procure the right size and to have all the rovings uniform. It must be remembered that changing the gear on the doffer shaft of the finisher does not change the weight of the roving when the finisher card is fed continuously from the second breaker; this gear simply changes the character of the feeding of the Apperly feed. If the slivers are crowded on the feed-apron and do not lie smoothly, a larger gear on the finisher doffer shaft will drive the feed-apron

faster and, consequently, spread out the slivers on the apron, rendering them less closely packed. The weight of the roving is generally changed by means of the gear on the doffer shaft of the second breaker; this is the best place, although it may be readily changed on the first breaker. The weight of the sliver from the first breaker and, consequently, the weight of the roving may be changed by the gear on the doffer shaft; a larger gear produces a heavier sliver, as it speeds up the feed-rolls of the card and also makes the dumping arrangement and feed-apron of the Bramwell feed, which is geared from the feed-rolls, work more rapidly. It may also be changed by changing the gear on the feed-rolls, which drives the dumping arrangement and feed-apron. The oftener the self-feed dumps, the heavier is the side drawing from the card.

Alterations in the weight of the first breaker sliver may also be made by changing the amount of wool deposited in the weighing pan of the self-feed. More wool is placed in the pan, or scales, if the weight that balances the pan is moved toward the extremity of the lever, or away from the pan. This is apparent, since more wool is required to overbalance the scale, and the elevating and stripping aprons are not stopped until the scale is overbalanced, the scale being the governing element.

49. Sizing Roving.—In order to find the size or run of the roving that a card is producing, it is necessary to measure a certain length and either find the size by means of a run scale or find the weight by means of a grain scale and then figure the run. If it is necessary to use a grain scale, it is convenient to have a table with the weight and size of a given length figured out. Sometimes 50 yards of yarn is measured and sometimes only 20 yards. Whatever the length, however, it is usually measured by means of a stick either 1 or ½ yard in length and 3 or 4 inches in width, around which a number of rovings are carefully wound until the length desired is obtained. Sometimes instead of using a stick for measuring the yarn, marks are made on a

post or on the wall exactly 1 yard or ½ yard apart. The required number of rovings is placed even with the top mark and allowed to hang loosely; they are then broken off squarely at the bottom mark. This insures an even and uniform length being weighed each time, as the tension is always the same. It is somewhat difficult in winding the rovings around a stick always to keep the same tension, and if this is not done a considerable error may be brought into the calculation, since the length weighed may vary in different cases.

50. The top and bottom spools of the condenser are always weighed separately and also spun separately, either on different mules or on separate sides of the same mule, it being possible to have different drafts on different sides of a woolen mule, thus allowing the same size of yarn to be spun even if there is some variation in the size of the roving.

The necessity for keeping the top and bottom spools, or all three spools in a three-deck condenser, separate, arises from the fact that it is impossible to set the doffers to the main cylinder absolutely the same. Then again the top ring doffer makes the first stripping from the main cylinder of the card, while the bottom doffer takes what is left on the cylinder. Although the rings of the top doffer are made narrower than those of the bottom doffer and its speed may be changed, there is a tendency for rovings on one spool to be heavier or lighter than those on the other. This necessitates making separate weighings from the top and bottom spools. If there is much difference in the weight of the rovings from the top and bottom doffers, the speed of the top doffer should be changed slightly; increasing its speed makes the rovings from the top doffer lighter, and decreasing it makes them heavier.

If the mules are running on half draft, it is customary instead of weighing 50 yards of roving to weigh 25 yards. This, of course, makes the reading of the run scale identical with the ultimate size of the yarn when it is spun, as the mule draws the roving out to twice its original length.

WOOLEN SPINNING

INTRODUCTION

1. The stock, after having been carded and converted into roving of a suitable size, is ready to be spun into yarn of the required run or cut. This involves two principal operations; namely, the drafting, which is a drawing out, or attenuation, of the roving, and the twisting, which, in reality, is the process that forms the roving into yarn. In addition, the yarn thus formed must be wound on suitable bobbins or formed into cops. These operations may be said to constitute the process of *spinning*.

The spinning of yarn from fibers of wool is one of the oldest textile arts known to history and in ancient times was performed by first drawing and twisting the thread by hand and afterwards winding the yarn thus formed on a round piece of wood 18 or 20 inches long. This constituted the first spinning and the piece of wood was the first bobbin, or spindle. The first advance in spinning was the one-thread spinning wheel, which consisted of a large wheel mounted in a frame and carrying a driving band or cord for imparting a rotary motion to the spindle, which was also carried in bearings in the frame. After this came the Hargreaves spinning jenny, which was really an adaptation of the one-thread spinning wheel to spin more than one bobbin of yarn. The next advance was the Crompton mule, which was in reality a hand jack. Following this, Roberts made the mule self-acting and introduced the quadrant for winding the yarn on the bobbins. From these, the present *woolen mule* has been evolved.

Before wool can be spun into yarn, it must be carded and converted into rovings, which, being wound on jack-spools, are placed on the mule; the roving is then unwound from the jack-spools, drafted, twisted, and wound in cops or on bobbins. In order that the resulting yarn may be as nearly perfect as it can be made, the rovings must be as free as possible from twits and bunches and also from foreign substances, such as broken burrs and other minute particles of vegetable matter; they should be round and firm, uniform in structure, and of such a size that the required number of yarn may be spun without an excessive attenuation, or drafting, of the roving during the spinning. As a rule, the longer the fiber, or the better the grade of stock, the greater is the draft that can be given in the spinning; short stock requires more roving to be delivered by the delivery rolls of the mule for every stretch of yarn. Low stock with from 50 to 75 per cent. of waste or shoddy mixed with it also necessitates less draft in spinning; the carder, therefore, must make the roving correspondingly lighter in weight to produce the required yarn. Certain wools also have much better spinning properties than others, owing to their fineness, elasticity, waviness, serrations, and other characteristics that determine the value of wools for different classes of goods. Such stock will spin much better and stand more draft than poorer material.

2. Quality of Roving.—There are, generally speaking, three kinds of roving spun into woolen yarn: (1) Roving made from inferior stock or from stock that is barely capable of spinning to the desired run; (2) roving that has been cut, rolled, or otherwise affected by poor carding; (3) roving that has been properly handled in all the previous processes and that will spin superior yarn.

Regarding the first class of roving little can be said, as it is so plainly inferior and the stock from which it is carded so short, broken, and generally unsuitable, that only uneven yarns irregular in structure and lacking in elasticity and strength can be made from it.

The second class is generally caused by carelessness. It is ordinarily expected that with a good grade of stock the product of the cards will, in spinning, be drawn out to twice the original length, thus greatly assisting in the removal of any possible lumps, bunches, or general irregularities. Good even roving can be easily drawn out to this length, or even more, but poor uneven roving, or that made from low stock, cannot.

The uneven bunches in roving of this class are a great hindrance in producing even yarn and require careful setting of the mule. The twist runs into the thin places in the roving first and twists them hard, thus forming twits in the yarn. At the same time there is a tendency of the mule to regulate uneven roving to a large extent, because as the thin places become twisted hard first they will not be drafted, or drawn out, while the bunches remaining soft are drawn out until they are nearly as small as the thin places, when the twist will commence to run into them. The spindles of the mule are turning all the time that the carriage is being drawn out and a certain amount of twist is put into the roving before the delivery rolls stop and the drafting action commences. Therefore, if the roving to be spun into yarn is full of bunches, it is a good plan to have the carriage come out slowly at first; this puts the twist into the thin places quickly and allows more time for the soft bunches to be evened up by the drafting. However, if roving contains very many large, uneven bunches, it is impossible to produce a perfectly even yarn, although the unevenness may be largely reduced in the spinning.

The third class of roving includes that which is well carded from good, even, sound wools and a round, even roving made. The mule will draw such roving to twice its original length, and even more, with very little trouble.

3. Operation of Spinning.—By the term **spinning** is meant a process that may be divided into three operations as follows: (1) The drafting of the roving, in order to reduce its diameter and increase its length until the desired size of

yarn is obtained. (2) The twisting of the attenuated roving, in order to give the yarn sufficient strength to be woven; on woolen mules this is partly combined with the first operation mentioned, namely, drafting. (3) The winding of the yarn prepared by the previous operations on bobbins or in cops in suitable form for the succeeding operations of weaving or spooling.

THE MULE

ELEMENTARY PARTS

4. The machine used in woolen spinning for accomplishing the above results is, owing to its hybrid nature, known as a **mule**; and on account of its practically automatic action is called a **self-acting mule.** It may be divided into two parts, each being equally essential in performing the objects named in the formation of the woolen thread; namely, the *head*, or *headstock*, which receives the driving power and from which all the motions of the mule originate, either directly or indirectly, and which is stationary and connected to the delivery rolls for delivering the roving; and the *carriage*, which bears the spindles that perform the functions of drafting and twisting the roving into yarn and then winding it on bobbins placed thereon, and which is movable.

In order that the principle of spinning and the fundamental action of the mule may be understood, the essential movements of the machine will be described first without reference to the complicated mechanisms that produce the various motions.

5. Referring to Fig. 1*, the jack-spool *a*, on which the roving to be spun is wound, is placed on a rotating drum a_1,

*The same letters of reference are used in all the illustrations of the woolen mule where the same parts are shown. This will be found a great aid in reading the illustrations and in becoming familiar with the machine. Figs. 4 and 5 are illustrations of the front and rear of the machine and should be frequently referred to in order that separate mechanisms may be associated, wherever possible, with the whole machine.

which turns the spool and unwinds the roving, allowing it to be passed through the stationary guide a_2 to the delivery rolls a_3, a_4, a_5. Thence the roving passes directly to the spindle c_1 and is wound on a bobbin c_2 placed on it; that is, after the roving has been drafted and twisted into yarn.

The delivery rolls of the mule are composed of three parts; the two bottom rolls a_3, a_4 are driven from the head-stock, while the top roll a_5 is made in sections, each consisting of two bosses that rest on the bottom rolls. The bosses may be removed in order to replace rovings that become broken between the delivery rolls and the jack-spool.

FIG. 1

Although only one spindle and one bobbin are shown, it must be remembered that each mule often contains as many as 280 or 300, and sometimes as many as 400.

The spindle c_1 is carried in two bearings—a bottom, or step, bearing and a top, or bolster, bearing. Between the bolster and the footstep, there is fixed on the spindle a small, grooved pulley c_4, called a *whorl*, that has an endless spindle band c_5 passed around it. This spindle band also passes around a tin cylinder c_6, called a *drum*, which supplies the motive power for turning the spindles by means of the spindle bands. The drum runs the full length of the carriage,

each spindle having a separate band that passes around its whorl and around the drum. The spindle is not absolutely vertical, but is inclined at an angle toward the delivery rolls. The spindles and drum are borne in a frame, or carriage, c, that is carried by transverse supports c_1 in the ends of which are bearings for the carriage wheels c_2. The latter run on iron rails c_3, so that if power is applied to the carriage it can readily be moved to or from the delivery rolls.

The yarn passes under a wire b fixed in the *sickle* b_1, which oscillates with the shaft b_2; this wire is known as the *faller wire*, or more definitely, the *winding faller*. Its object is to guide the yarn on to the bobbins during the operation of winding. The yarn also passes above the wire b_3 that is attached to the sickle b_4, the sickle, in turn, being fastened to the shaft b_5. This is known as the *counter*, or *tension, faller* and is for the purpose of keeping tension on the yarn during the winding in order to prevent kinks and soft-wound bobbins.

6. Converting the Roving Into Yarn.—The method by which this mechanism produces yarn is as follows: The carriage is brought close to the delivery rolls, so that the points of the spindles are within a short distance of the point of contact between the delivery rolls where the yarn is delivered. As the delivery rolls combined with the drum a_1 begin to deliver the roving, the carriage simultaneously commences to recede from the rolls at practically the same speed as that at which the roving is delivered, and the spindles begin to rotate. When the spindles reach the point a_4, the position of which depends on the draft of the roving, the delivery rolls and the spool drums stop, but the carriage continues to recede until the points of the spindles are about 72 inches from the delivery rolls. By this means the roving is drafted, or drawn out, to twice its original length or thereabouts.

As these operations are taking place the twist is being put into the yarn by the rotating spindles; this is accomplished by the slipping of each turn of yarn over the end of the bobbin and spindle, which is due to the inclination of the latter; Fig. 2

illustrates this point. If the spindle were vertical and the point of delivery at the rolls a_3, a_4, a_5 level with any point on the bobbin c_6, the yarn would tend to be wound on the bobbin at that point when the spindle was put in motion. The spindle, however, is set at an angle and the point of delivery is slightly above the top of the bobbin; thus, when the spindle rotates, the yarn rises on the bobbin in a series of spiral coils, the tendency of the thread being to assume a position at right angles to the spindle, which would be at the point a_7, provided that the spindle and bobbin were long enough.

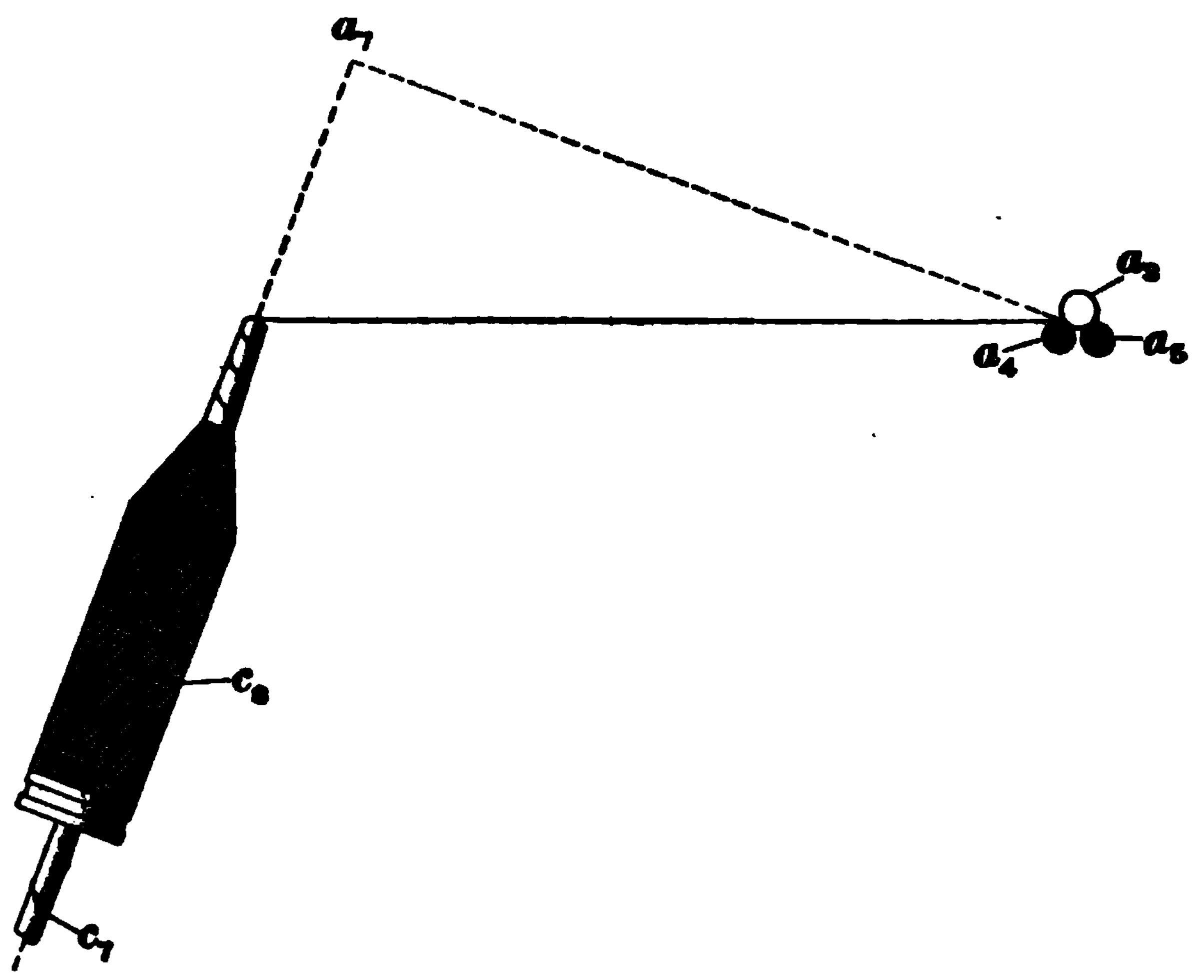


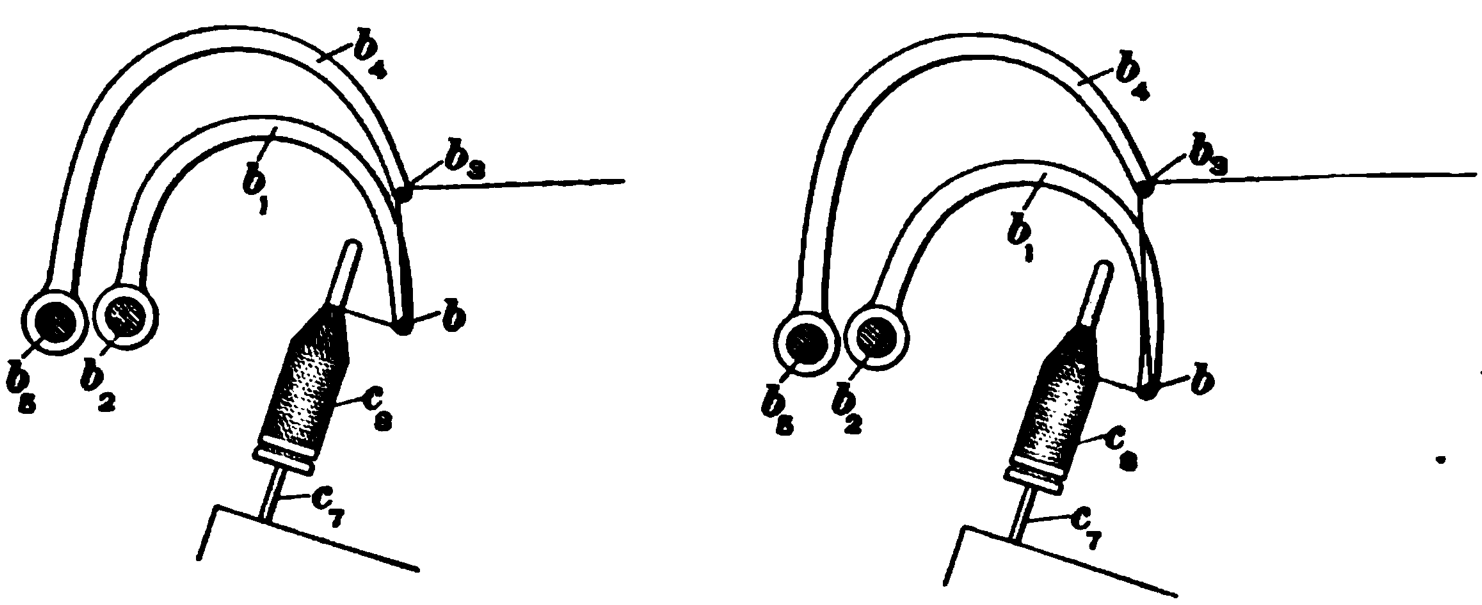
FIG. 2

The tendency of the yarn to rise continues until the top of the bobbin is reached, when the yarn slips over the end of the bobbin, thus putting in one turn of twist. As the spindle continues its rotation, each coil of yarn rises and slips over the end of the bobbin, thus putting as many turns of twist into the yarn as there are revolutions of the spindle.

It is the combined drafting and twisting action of the woolen mule that gives to the woolen thread its distinctive woolen formation, or covered appearance. In spinning other yarns, the roving is first drafted to the required size by means of two or more pairs of rolls, each successive pair running

at an increased speed, and then twisted into yarn, the operations of drafting and twisting being entirely separate; in other words, the yarns are *roll drawn.* Woolen yarn, however, is drafted and twisted at one and the same time; the yarn being spoken of as *spindle drawn*, because the spindle draws the roving to the required size, while in the other case this is accomplished by means of rolls.

When the carriage reaches the end of its stretch—when the spindles are at their greatest distance from the rolls—it is stopped and is held while more twist is put into the yarn; the full amount of twist is not put in while the carriage is coming out, because if it were the yarn could not be drawn



(a) (b)

FIG. 3

out, but would break instead, since the twist gives the yarn strength and prevents the individual fibers from being drawn past each other as is necessary in order that the roving may be drafted. This extra twist is sometimes put in by means of an accelerated motion.

At the completion of the twisting motion, the spindle is stopped and reversed for a few turns, so that the few coils of yarn between the top of the bobbin (which is flush with the top of the spindle) and the yarn already spun, are unwound. This operation is technically known as *backing-off;* as it takes place the faller b, Fig. 1, descends and assumes a position for guiding the yarn on to the bobbin, while the counter faller b_3 ascends so as to obtain the requisite tension of the stretch of yarn for winding it on to the

bobbin and to prevent the formation of kinks. The position of the winding and counter fallers after the backing-off takes place and just as the stretch of yarn is ready to be wound on the bobbin is shown in Fig. 3 (*a*).

Immediately after the backing-off is completed, the *drawing-in* of the carriage is commenced and the spindles are revolved in their normal direction so as to wind the yarn on to the bobbin as it is released by the inward run of the carriage. As this takes place the winding faller *b* first descends quickly to the position shown in Fig. 3 (*b*) and then rises slowly until it again assumes the position shown in Fig. 3 (*a*). The result of this is that the yarn is first wound on the bobbin in a series of coarsely pitched descending coils and then in a series of finely pitched ascending coils. Thus each stretch of yarn is wound on the bobbin in two layers, the coarsely pitched layer giving the bobbin strength and solidity and the finely pitched layer serving to place the remainder of the yarn in the stretch on the bobbin. This motion of the winding faller is regulated by what is known as the *builder rail*.

When the inward run of the carriage is completed, the winding operations cease; the winding faller and counter faller assume their normal positions clear of the yarn, Fig. 1, and the parts are again adjusted to begin the work of drafting and twisting. The complete outward and inward run of the carriage is technically called a *draw*.

7. The **driving** of the principal parts of the mule may be briefly stated as follows: The roving motion, i. e., the motion for the delivery of the roving, is driven by bevel gears and a cross-shaft from the headstock of the mule. The drum in the carriage, which imparts motion to the spindles, is driven by means of an endless rope, called the *rim band*, from grooved pulleys on the main shaft. The rim band, however, only drives the spindles while the carriage is coming out and while twist is being put into the yarn by the accelerated speed; when the yarn is being wound on the bobbin, the spindles are driven by the motion of the carriage, which unwinds a chain called the *quadrant chain* from a

Fig. 4

chain drum connected to the shaft of the drum that drives the spindles. The carriage is drawn out by means of a scroll on the drawing-out shaft of the headstock and is drawn in by means of two scrolls on the drawing-in shaft.

DETAILS OF CONSTRUCTION AND OPERATION OF THE MULE

8. Classification of Operations.—The brief description given enables the movements of the woolen mule to be classified as follows: (1) delivery of roving, (2) drafting and twisting, (3) backing-off, (4) winding, (5) reengagement. It is somewhat difficult to understand the movements of the various parts of the mule at different periods because of the fact that at one time a certain portion of the mechanism may be performing a certain function, while at another time it may be performing a totally different one, both the velocity and direction of its motion being changed. Each of the essential mechanisms of the mule will now be described in detail, and in studying these descriptions reference should be made not only to the illustrations of these various mechanisms, but also to other illustrations in which they may be incidentally shown, and also to Figs. 4 and 5, which show the positions of many of these parts and their relation to the mule as a whole.

9. Headstock.—As has been said, the mule consists of two parts, from one of which, the **headstock**, all other parts receive their motion. The sectional view shown in Fig. 6 illustrates the method of transmitting the power to the various mechanisms.

The main shaft e receives and transmits the motive power by means of which the various operations are performed, and is for this purpose provided with four pulleys e_1, e_2, e_3, e_4. These pulleys are commonly spoken of, in their respective order, as the first, or loose, pulley; the second, or drawing-in, pulley; the third, or drawing-out, pulley; and the fourth, or accelerated-speed, pulley. In addition, the main shaft also carries two grooved pulleys e_5, e_6 and three gears e_7, e_8, e_9.

FIG. 5

Fig. 6

The drawing-out pulley e_3, grooved pulley e_6, and gears e_8, e_9 are keyed to the shaft; the others are loose. The pulley e_2 is provided with a sleeve, on which the pulley e_1 runs loose but to which the gear e_7 is fastened; the grooved pulley e_5 is keyed to the sleeve of the pulley e_4. As a result of this arrangement, the pulley e_1 acts simply as a loose pulley and furnishes a resting place for the driving belt when motion is not being imparted to any part of the mule; the pulley e_2 imparts motion to the gear e_7; the pulley e_3, to the gears e_8, e_9 and the grooved pulley e_6; and the pulley e_4, to the grooved pulley e_5. It should also be noted that when the driving belt is on e_4 the pulley e_5 will drive the shaft e and, consequently, the gears e_8, e_9, by means of the rim band h, which passes around the grooved pulleys e_5, g_1, e_6; in this case e_6 is the follower and e_5 the driver. When the mule is not in operation the driving belt runs on the loose pulley e_1, from which it may be moved to the pulleys e_2, e_3, e_4 by means of a belt lever.

ROVING MOTION

10. At the commencement of the spinning operation, the carriage is in near the headstock so that the spindles are close to the delivery rolls, and as the mule is started, two motions are brought into play; namely, the *roving motion*, for delivering the roving, and the *drawing-out motion*, which causes the carriage to recede from the delivery rolls. The roving motion here described is so arranged that the delivery rolls and spool drums on one side of the mule may be stopped independently of those on the other side, thus allowing yarns of two sizes to be spun on the same mule, or allowing the same size yarn to be spun from two different run rovings. For this reason this motion is known as a *double roving motion*. The driving belt at the start is shifted from the loose pulley e_1 to the third pulley e_3, Fig. 6, and the power transmitted to the gear e_{12} through gears e_9, e_{10}, e_{11}. From the gear e_{12}, motion is communicated to the delivery rolls of the mule through gears e_{13}, e_{14}, and e_{17} and e_{18} on the cross-shaft e_{19}, as shown in Fig. 7.

Fig. 8 is a plan view of this double roving motion, while Fig. 9 is a side elevation of one side of the same mechanism, representing Fig. 8 as it will appear when looked at in the direction of the arrow. The bevel gear e_{14} meshes with another bevel gear a_{13}, which, together with the halves a_{16} of two toothed clutches, is fastened to a sleeve a_{11} that is loose

Fig. 7

on the shaft of the rear bottom delivery roll a_8. When these clutches are out of contact, as shown in Fig. 8, no motion is imparted to the delivery rolls of the mule, but when the parts a_{14} are moved in contact with the parts a_{15}, by the yoke levers d_2, the motion of the gear a_{16} is imparted to the rear delivery roll a_8 and also through the gears a_9, a_{10}, a_6, to the

FIG. 8

Fig. 9

front delivery roll. The halves a_{14} of the clutches have two projections extending into slots in the brake bosses a_{15}, so that although they are free to be moved along the shaft so

i_4

Fig. 10

as to engage with a_{15}, they will impart motion to a_4 when so engaged. The top roll a_3, which consists of loose bosses,

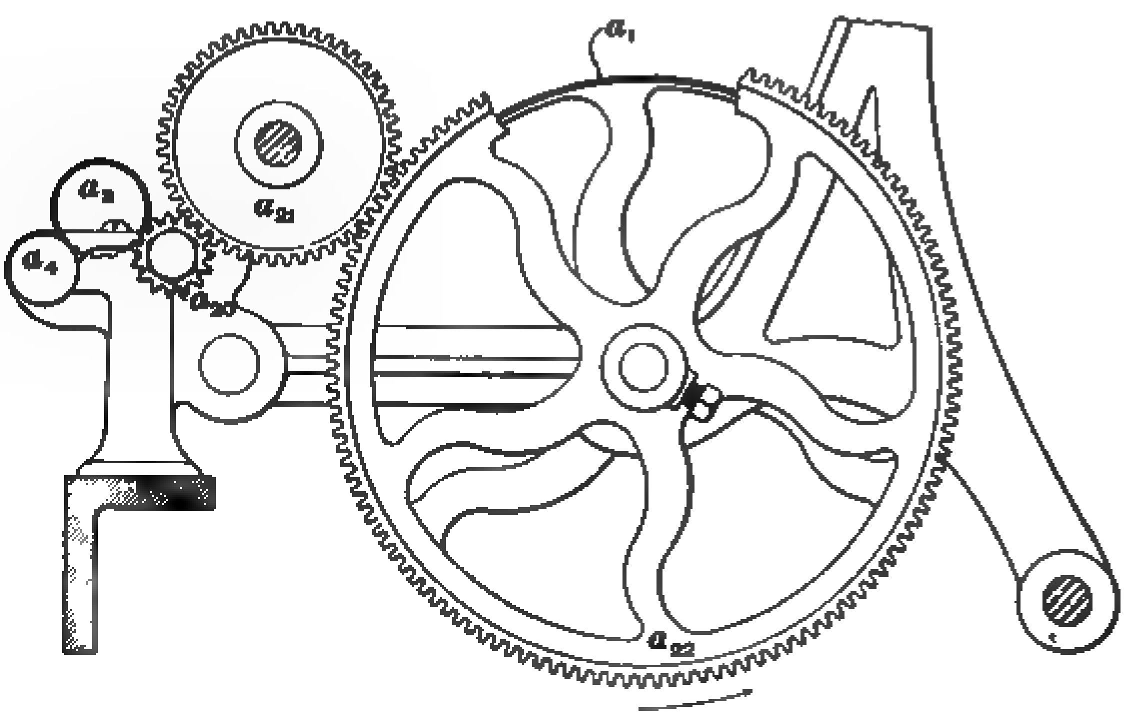


Fig. 11

is not driven positively, but receives its motion from the two bottom delivery rolls, on which it rests, being thus rotated only by frictional contact with the bottom rolls. The spool

drums, which carry the spools of roving and unwind it as it is taken by the delivery rolls, are geared from the shaft of the rear delivery roll at each end of the machine. As shown in Fig. 11, a gear a_{20} drives an intermediate gear a_{21} that in turn imparts motion to the gear a_{22} and spool drums a_1. The gear a_{20} is a change gear and may be changed in size if in any case the spool drums unwind the roving faster or more slowly than it is taken by the delivery rolls. The motion of the delivery rolls is of necessity intermittent, since the roving is delivered during only a portion of the time that the carriage is receding from them; this is necessary so that the drafting of the roving may take place in order to reduce its size and produce yarn of the required run.

11. The motion of the delivery rolls and spool drums may be checked by means of the *roving stop-motion*, Figs. 8 and 9, at any point, so that any desired length of roving may be delivered for each draw of the mule. The point at which the delivery rolls stop, and consequently the length of roving delivered, is regulated by means of a roving-pin gear for each side of the mule; the pin gear d for the left-hand side is shown in Fig. 8, while the other is removed in order to show the mechanism of the stop-motion more clearly. The yokes d_2, which operate the sliding portions a_{14} of the delivery-roll clutches, and the castings d_1, which carry the roving-pin gears, are rigidly fastened together, and are fulcrumed at d_3; thus, if motion is imparted to them the clutches will be thrown in contact and the roving-pin gears moved forwards so as to mesh with the worms a_{11}, which are fastened to the shaft of the rear delivery rolls a_3. This is accomplished each time that the carriage comes in to the delivery rolls by means of a roll c_6, Fig. 9, that presses down a lever i cast in one piece with the shaft i_6. The motion of this shaft is imparted to the finger i_1 and a strong, flat spring i_3 by means of the casting i_2, which is cast in one piece with the shaft i_6 and carries a setscrew by means of which the finger i_1 may be adjusted. As the spring i_3 moves

forwards, it moves the casting d_1 and yoke d_2 around the fulcrum d_3, thus forcing and holding together the parts a_{14}, a_{15} of the delivery-roll clutch, and also holding the roving-pin gear in contact with the worm a_{11}. As the finger i_1 is moved it is caught and held against the tension of the spring i_4 by a dog d_5 that is constantly pressed against it by means of a coil spring d_7 on the stud on which it is fulcrumed. Motion being imparted to the gear a_{16} as described, the delivery rolls and also the roving-pin gears are rotated. This motion continues until a pin d_8 placed in a hole in the roving-pin gear comes in contact with a wedge-shaped piece of steel d_4 screwed to the dog d_5. When the pin strikes this wedge, the dog is forced from contact with the finger i_1 and a strong spring i_4 attached to the finger pulls it backwards, thus moving the casting d_1 and yoke d_2 and disengaging the delivery-roll clutches and roving-pin gears, so that the motive power is withdrawn.

12. In order that the delivery rolls may stop instantly when the power is withdrawn, friction brakes are applied at the same time, thus checking any momentum that the rolls may have and also firmly locking them in place until they are ready to deliver the roving for another draw of the carriage. These brakes are shown in Figs. 8 and 9 and also, in detail, in Fig. 10. A boss a_{17} that is fastened to the shaft of the rear delivery roll is encircled by a friction strap a_{18}, one end of which is fastened to the framework of the mule, while the other is attached, by means of a short length of chain a_{19}, to the stud i_3 on the finger i_1; thus, as the finger i_1 is pulled backwards by the spring i_4 to disengage the roving motion, it also tightens the chain a_{19} and applies the brake to the delivery rolls.

A strap d_{10} is fastened by a pin d_8 to the roving-pin gear and is carried back over a small pulley. At the end of this strap is attached a weight that revolves the pin gear in the opposite direction as soon as it is released from the worm, thus bringing it back to its initial position, with the pin d_8 resting against the back of the wedge d_4.

In order to prevent tampering with the roving-pin gears, a circular plate d_{11}, partly shown on one side in Fig. 8, is placed over them and fastened with a small padlock d_8. With this plate in position it is impossible for the pin d_6 to be moved from one hole to another or be accidentally displaced.

13. Each roving-pin gear contains two rows of holes with 44 holes in a row. Those in the outside row are known as *full holes*, while those in the inside row, as each is placed between 2 holes of the outside row, are known as *half holes*, since it is possible by their use to obtain an adjustment of the length of roving delivered equal to one-half that obtained by moving the pin 1 hole in the outside row. The setting of the pin d_6 so as to deliver any desired length of roving before the delivery rolls of the mule stop is determined by the fact that for each full hole in the roving gear $2\frac{1}{2}$ inches of roving is delivered, while for each half hole $1\frac{1}{4}$ inches is delivered; that is, by changing the pin from a full hole to an intermediate half hole or from a half hole to the next full hole the length of roving delivered is varied $1\frac{1}{4}$ inches. This may be easily proved by figuring from the diameter of the delivery rolls, as follows: The diameter of the delivery rolls is $1\frac{3}{16}$ inches; therefore, their circumference is $1\frac{3}{16}$ inches $\times 3.1416 = 3.73$ inches. The worm a_{11} is triple-threaded, and consequently moves the roving gear 3 teeth to each revolution of the delivery roll. The roving gear contains 88 teeth and 44 full holes; therefore, 2 teeth in the gear are equal to 1 full hole, and 1 full hole is equal to two-thirds of a revolution of the delivery roll; that is, two-thirds of 3.73 inches, or practically $2\frac{1}{2}$ inches. A half hole of course is equal to one-half of $2\frac{1}{2}$ inches, or $1\frac{1}{4}$ inches.

Knowing the length of roving controlled by each hole in the roving gear, the number of holes to be allowed can be easily ascertained after the desired length of roving to be delivered has been found. For instance, suppose that 40 inches of a certain run roving must be delivered to spin yarn of a required run and it is desired to ascertain how

many holes to allow in the roving-pin gear to deliver this amount of roving. All that is necessary is to divide 40 by 2½, which will give 16 holes as the number to allow. With soft roving, however, it is very difficult to figure exactly how many holes will be necessary, but the above method will approximately give the correct result, and then if the yarn spun is too light or too heavy, the pin can be changed a half hole or a full hole, etc., as may be required. If it is desired to change the roving-pin gear so as to spin yarn of different run from the same run roving, or so as to spin the same run yarn from a different run roving, the number of holes to allow may be found by proportion. For instance, suppose that with a certain run roving 18 holes give 2½-run yarn and it is desired to spin 3-run yarn. Letting x represent the number of holes that must be allowed, the proportion is $3 : 2\frac{1}{2} = 18 : x$; x is therefore 15, and 15 holes must consequently be allowed in the roving gear to spin 3-run yarn from that particular run roving. For another example, suppose that with an allowance of 20 holes in the roving gear a mule is spinning a certain run yarn from 2½-run roving and that it is desired to spin the same run yarn from 2-run roving. The number of holes to allow in the roving gear to accomplish this may be found by the following proportion: $2\frac{1}{2} : 2 = 20 : x$; x is therefore 16—the number of holes required.

DRAWING-OUT MOTION

14. The **drawing-out motion** is in operation at the same time that the roving motion is delivering the roving, and causes the carriage to recede from the delivery rolls so as to draft and twist the roving into yarn. The driving belt during this period is in contact with the third pulley and imparting motion to the gear e_{11}, Fig. 6. Attached to the gear e_{12} is one-half e_{13} of a toothed clutch; the other half e_{14} may slide along a key on the shaft f so as to engage with e_{13}, in which case motion will be imparted to the shaft f and to the draft scroll f_1 fastened to it. The draft scroll is made with two separate and opposite scrolls, to one of which the rope f_2 is attached, as shown in Fig. 12. This rope, or

Fig. 12

band, as it is called, passes from the scroll around a binder pulley f_{11} and is attached to the carriage. As the middle part of the rope f_2 is omitted, a dotted arrow has been inserted to indicate the connections between the two ends. The binder pulley is movable in a slotted casting attached to the floor and is adjusted by means of a screw, to which a crank-handle may be attached for the purpose of tightening the band. Another rope f_3 is attached to the other scroll and is also attached to the carriage. These ropes are so connected with the scrolls that when the rope on one scroll is winding up, it is unwinding on the other. The result is that when one scroll is full, as the front one in Fig. 12, the other is empty. In Fig. 6 also the scroll f_1 has been shown in this condition. The diameters of the active parts in both scrolls, however, are always equal; otherwise, one of the ropes f_2 or f_3 would at certain times either be slack or too tight. Therefore, when the rope f_2 is winding up on the small diameter of its scroll, the rope f_3 is unwinding from the small diameter of the other scroll, and vice versa. The greater the diameter of the active part of the scroll, the greater will be the speed of the rope and, consequently, that of the carriage. When the carriage is being drawn out, the band f_2 is being wound up on the scroll and, as it passes over the binder pulley f_{11} and is attached to the carriage, it is this band that really draws out the carriage. The other band f_3 on the draft scroll has no real function in connection with actually drawing out the carriage, but simply furnishes a positive connection between the draft scroll and the carriage. This prevents any liability of the momentum of the carriage carrying it forwards faster than it is drawn out by the draft scroll and rope f_2; prevents the draft scroll from overrunning when the carriage comes in again; and also enables the position of the draft scroll to be changed, as will be explained later.

15. In order fully to appreciate the method adopted for drawing out the carriage by means of a draft scroll, it is well to understand the reason for its adoption. In the first place, the carriage moves out very fast in the first part of its motion,

in order to keep pace with the delivery of roving by the delivery rolls of the mule. When the delivery of roving stops, the speed of the carriage is immediately checked, and spinning, or the combined drafting and twisting of the roving, commences. Such an action is necessary for the carriage, since, if it commenced the draw by moving slowly, there would be so much twist put into the roving at the start, before it was drafted, or drawn out, at all, that it would be impossible afterwards to draw it to the required size of yarn. The variable speed thus necessitated is provided for by the draft scroll.

When the mule is started, the rope f_2 is on the large diameter of the scroll, at its center, and the carriage is thus given the speed necessary for keeping the delivery of roving at the required tension. As the delivery of roving is stopped, however, the drawing-out band commences to be wound down on the smaller part of the scroll, so that the speed of the carriage is gradually checked, thus allowing for the drafting and twisting of the roving. The carriage runs very slowly when near the end of its outward movement. The point at which the speed of the carriage is slowed by allowing the drawing-out band to wind on the smaller part of the scroll is controlled by the position of the scroll, which is regulated to suit different conditions of stock and roving.

16. The band f_2, Fig. 12, after passing around the binder pulley f_{11} is attached to a drum f_7, which is loose on the shaft c_{11}. The band f_3 passes over guide pulleys f_4, f_5 attached to the carriage, and is also fastened to the same drum as the band f_2, but is wound on it in the opposite direction. In the center of the drum f_7 is a worm-gear f_8 that engages with a worm f_{13} fastened to a shaft f_9. This worm may be turned by means of the crank f_{10}, which will rotate the drum f_7, winding up the band f_2, and unwinding the band f_3, or vice versa. This changes the position of the draft scroll relative to that of the carriage. It is sometimes desirable to do this, in order to adapt the drafting, or the speed of the carriage during the earlier part of its movement, to

the particular stock in hand. For instance, if roving that will not admit of much drafting is being spun and an extra amount of roving is being delivered, it will be desirable to turn the drum f_7 in such a direction that the band f_8 will start to wind on the draft scroll in such a position that a greater length of time will be required before it commences to wind down on the low part of the scroll, thereby making the carriage move rapidly for a greater distance at the start. This has the effect of allowing less twist to run into the roving before the drafting of the roving into yarn commences. This means of adjustment is only used, however, where a small change in the speed of the carriage is desired. The position of the draft scroll may be changed while the carriage is coming out or while the accelerated speed is in operation, but should not be changed while the carriage is in and the clutch e_{13}, e_{14}, Fig. 6, locked, as this puts an extra strain on either band f_8 or f_3 while the other becomes slack; this is apt to strip the teeth from the worm-gear f_6.

The small roll f_4, supported by brackets fastened to the frame of the carriage, prevents the drawing-out band from chafing on the carriage when it is in.

The part of the draft scroll where the drawing-out band winds down on to a smaller diameter, and where the speed of the carriage is thus checked, is composed of a flat, malleable-iron spiral, or wing, f_1, that is bolted or screwed to the side of the scroll, so that it can be removed and a wing of different shape substituted, to accommodate the speed of the carriage to any particular stock. The draft scroll is the only scroll that needs removable wings, as this scroll controls the motion of the carriage while the yarn is being spun, during which the character of the resulting yarn and the ease with which it is spun is largely dependent on the motion of the carriage.

17. The drum f_7 is made in halves that are provided with toothed ends, which lock them together after the manner of a toothed clutch; a coil spring on the shaft c_{11} presses the halves together and thus keeps them locked. Cast in one

piece with the half on which the band f_3 is wound is the worm-gear f_8. The object of this arrangement is to allow an adjustment, in addition to the movable sheave f_{11}, for taking up the slack of the drawing-out bands as they stretch through wear. If the sheave f_{11} has been moved as far as possible and the drawing-out bands are still slack, the sheave may be moved back, so as to slacken the bands as much as possible, and then the two halves of the drum f_7 separated and the shaft f_9 rotated by the handle f_{10} until all the slack is taken out of the bands; this still allows a full length of travel of the sheave f_{11} for further adjustment of the tension of the drawing-out bands should they continue to stretch.

DWELL MOTION

18. The object of the **dwell motion** is to afford relief to the roving as the carriage starts away from the delivery rolls, since there is a tendency for the carriage slightly to strain the roving at this point, owing to the fact that it tends to start rather abruptly on its outward journey. As no twist has as yet been inserted in the roving, it is also more liable to be strained at this time than at any other. The dwell motion, therefore, is an important mechanism, especially if the roving is soft and tender, since it prevents twits and unevenness in the yarn that would otherwise be unavoidable except with very strong roving. This relief is given the rovings by causing the carriage to dwell for an instant before attaining its maximum speed, which necessarily occurs during the first part of its motion away from the delivery rolls. The dwell motion is shown in detail in Fig. 13, but, as shown in Fig. 12, is really a part of the drawing-out motion.

In Fig. 13, the various parts of the dwell motion are shown in the positions that they assume when the carriage is drawn in, just previous to its outward journey. The shaft f_9 is free to move for a limited distance in the direction of its axis; that is, it may be thrust forwards or backwards, carrying with it the worm f_{13} and thereby imparting a slight

motion to the worm-gear f_8 and drum f_7. The effect of this motion therefore is the same as though the crank f_{10} were turned, with the exception that the effect is not permanent, as will be explained. A rack j is fastened to the floor in such a position that as the carriage reaches the end of its inward motion and approaches the delivery rolls it is engaged by a segment gear j_1 that is loose on the shaft c_{11}. As this segment gear engages with the rack the motion of the carriage imparts a movement to it that is transmitted to the segment gear j_2 and shaft j_3, to which j_2 is fastened. An

FIG. 13

arm j_4 is also attached to the shaft j_3 and is connected by a link j_5 to a slide j_6 that is free to move in a longitudinal direction on a girt c_{16} extending from the front to the back of the carriage frame. This slide is connected to the shaft f_8 by an extended arm fitting between the worm f_{11} and a collar j_8 setscrewed to the shaft. The effect of the motion imparted to the segment gear j_2 is to turn the shaft j_3 and raise the arm j_4, as shown in Fig. 13, which results in the connecting link j_5 drawing the slide j_6 and, therefore, the shaft f_8 and worm f_{11} forwards, or toward the front of

the carriage. This imparts a slight motion to the worm-gear f_6 and drum f_7, and thus winds up a short length of the band f_2 and likewise unwinds some of the band f_3. Normally, that is, when the carriage is away from the delivery rolls and the segment gear j_1 disengaged from the rack j, the arm j_3 is lowered and, as it rests on the link j_4 just below the dead center, it locks the shaft f_9 in its backward position; that is, in a position thrust away from the front of the carriage.

The way in which this mechanism imparts an initial dwell to the carriage is as follows: When the carriage is drawn in, the segment gear j_1 engages the rack and moves the drum f_7, raising the arm j_3, as shown in Fig. 13. As the carriage starts on its outward motion the draft scroll commences to wind up the rope f_2, but instead of drawing out the carriage, the initial movement of the rope f_2 turns the drum f_7, thus forcing the worm f_{13}, shaft f_9, and slide j_5 from the front of the carriage, drawing down the link j_4 and arm j_3 to their locked positions, and, through the segment gear j_2, imparting a motion to the segment gear j_1 in the opposite direction to that imparted by the rack j. The result of this is that the movement of the segment gear against the stationary rack imparts a slow movement to the carriage until the arm j_3 is lowered to its locked position and the segment gear is clear of the rack, whereupon the full speed will be imparted to the carriage by the draft scroll in the ordinary manner. All this movement is accomplished in a comparatively short time, but it allows just sufficient dwell at the start of the outward movement of the carriage to prevent any undue strain on the roving. More or less dwell may be given by raising or lowering the connecting link j_4 in the slotted casting j_3, which allows more or less thrust to the shaft f_9 and worm f_{13} and, consequently, a greater or less movement to the drum f_7.

SQUARING BANDS

19. It is impossible to construct the carriage of the mule so that it will be perfectly rigid, on account of its great length; consequently, since it is driven in the center only, there is a tendency for the carriage to warp so that the spindles will not form a line parallel to the delivery rolls. This tendency, which exists when the carriage is being drawn in as well as when it is being drawn out, is overcome by means of squaring bands. Several drums, one of which, c_{13}, is shown in Fig. 4, are keyed to a shaft that is carried in bearings just beneath the carriage and extends its whole length. The number of drums placed on this shaft depends on the length of the carriage, but generally there are three, one at each end and one in the center. A rope, or band, c_{14}, Fig. 4, is wrapped several times around each drum to prevent any slipping; one end of the band is fastened to a casting bolted to the floor at the front of the mule, while the other is fastened to a similar casting at the back of the mule.

As a result of this arrangement, whenever the carriage moves, the motion of any one portion is immediately transmitted by the shaft to each drum and squaring band, so that all parts of the carriage will move in unison. In order to work properly the squaring bands must be kept tight; this may readily be accomplished by means of ratchets and pawls attached to the castings to which the bands are fastened.

DRIVING OF SPINDLES

20. During the time that the carriage is receding from the delivery rolls, and also while the twist is being placed in the yarn by the accelerated speed, the spindles are being turned by a rope h, known as a **rim band**, which is driven by means of the two grooved pulleys e_4, e_6, Figs. 6, 7, 14, and 15, on the main shaft e. The spindles are, of course, turning all the time that the carriage is being drawn out, being driven in this case by the smaller grooved pulley e_6, which is fast on the main shaft e, as is also the third

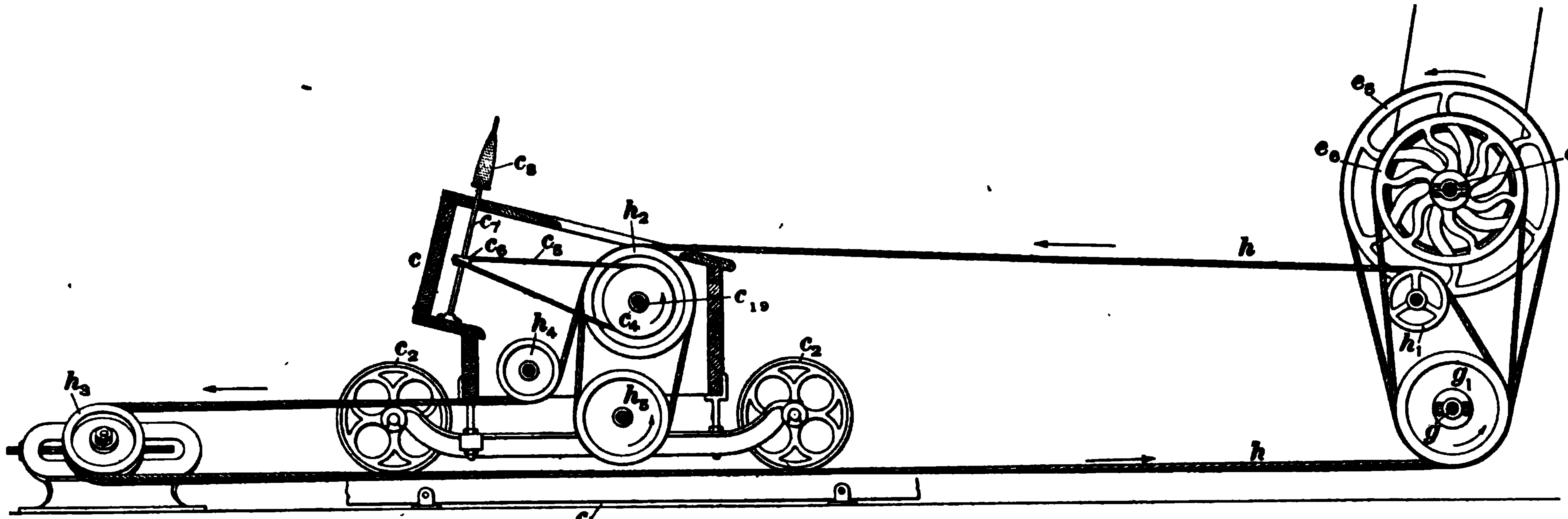


FIG. 14

pulley e_3, to which the belt is at that time furnishing the power for drawing out the carriage. While the rim band is driven by the smaller grooved pulley e_6, the larger grooved pulley e_5 is simply a follower; but when the carriage is drawn out to its full extent, the driving belt is shifted from the third

(a) (b)

FIG. 15

to the fourth driven pulley e_4, and the rim band is driven by the larger grooved pulley e_5, the smaller grooved pulley e_6 being a follower. In this case motion is imparted to the main shaft e by e_5, since e_4 and e_3 are both loose on the shaft. When the larger grooved pulley is the driver, the spindles are driven at a higher velocity than when the smaller grooved

pulley is the driver; this is called the **accelerated speed** and is for the purpose of saving time in putting in the requisite amount of twist after the yarn is drafted. The rim band in this mule is carried through the machine twice, and is known as a *double rim band.* Besides the grooved pulleys on the main shaft, the rim band is passed around a grooved pulley g_1 on the drawing-in shaft g, by means of which the direction of rotation of the spindles is reversed when the carriage backs off. It is also passed around the guide pulleys h_1, h_4, h_5, Fig. 14, around the grooved pulley h_2 on the drum shaft of the carriage, by means of which the motion is communicated to the spindles, and around a binder pulley h_3 that may be moved in a slotted stand attached to the floor for the purpose of adjusting the tension of the band.

21. The driving pulleys e_5, e_6, Fig. 6, on the main shaft are each made in different sizes, so that almost any speed of the spindles may be obtained without altering the speed of any other part of the machine. The slow-speed, or smaller, grooved pulley e_6 is made 11, 12, 13, 14, 15, 16, 17, 18, or 19 inches in diameter, while the fast-speed pulley e_5 is usually made 19, 21, or 22 inches in diameter. The grooved pulley h_2 on the center, or cylinder, shaft of the carriage is 10 inches in diameter. The spindle-band cylinder c_4, Fig. 14, is usually about $6\frac{1}{4}$ inches in diameter and the whorl c_6 on the spindle, 1 inch.

22. In order to find the speed of the spindles, therefore, the following rules are necessary.

To find the speed of the spindles when the driving belt is on the third pulley:

Rule I.—*Multiply the revolutions per minute of the main shaft by the diameter of the smaller grooved pulley and by the diameter of the spindle-band cylinder; divide the result thus obtained by the product of the diameter of the driven grooved pulley on the cylinder shaft and the diameter of the whorl on the spindle.*

Example 1.—The main shaft e, Fig. 14, makes 320 revolutions per minute and the smaller grooved pulley e_6 is 18 inches in diameter; the

driven grooved pulley h_2 on the cylinder shaft in the carriage is 10 inches in diameter; the cylinder c_4 is $6\frac{1}{4}$ inches; and the whorl c_6 on the spindle is 1 inch in diameter. What are the revolutions per minute when the driving belt is on the third pulley?

SOLUTION.— $\frac{320 \times 18 \times 6\frac{1}{4}}{10 \times 1} = 3{,}600$ rev. per min. of spindles.

To find the revolutions per minute when the belt is on the fourth pulley and twist is being put in the yarn by the accelerated speed:

Rule II.—*Multiply the revolutions per minute of the main shaft by the diameter of the larger grooved pulley and by the diameter of the spindle-band cylinder; divide the result thus obtained by the diameter of the driven grooved pulley on the cylinder shaft multiplied by the diameter of the whorl on the spindle.*

EXAMPLE 2.—What would be the accelerated speed of the spindles in the mule given in example 1, if the larger grooved pulley e_2 were 22 inches in diameter?

SOLUTION.— $\frac{320 \times 22 \times 6\frac{1}{4}}{10 \times 1} = 4{,}400$ rev. per min. of spindles.

In the case of example 1, the spindles would revolve from 1 to 2 per cent. more slowly than figured, owing to the carriage and the rim band traveling in the same direction. This does not happen when the accelerated speed is on, because the carriage is drawn out to the full extent before the belt is shifted on to the fourth pulley. However, in a machine of so complicated a nature as the mule, there is more or less slippage and loss of power, and it is therefore customary to deduct 5 per cent. from the foregoing results in each case, in order to approximate the actual speed of the spindles. This also allows for the fact that the diameter of the whorl and drum should be taken at points representing their effective diameters; that is, for more accurate calculations the thickness of the spindle band should be added to the diameter of both the tin drum and the spindle whorl.

23. Since the rim band is a continuous band running through the machine twice, in different grooves on the same pulleys, it must necessarily be crossed at some point, in

order to bring it back to its starting place. If the band were not crossed it would necessitate the use of two bands running side by side and having two splicings, whereas the crossing of the band makes only a single splice necessary. The rim band is crossed, as shown at Fig. 14, between the binder pulley h_2 and the grooved pulley g_1 on the drawing-in shaft.

The band runs in the direction indicated by the arrows on Fig. 14 during the slow speed of the spindles; that is, while it is driven by the pulley e_4, and also while the spindles are being driven at an accelerated speed by the large grooved pulley e_3. During the backing-off of the spindles, however, the rim band is driven by the grooved pulley g_1 on the drawing-in shaft and its direction reversed, in order to reverse the motion of the spindles and wind the yarn down the bobbin previous to winding the stretch of yarn on it.

Fig. 15 (a) is a view of the rim band as it appears from the front, or carriage, side of the mule, showing the method of passing the band around the driving pulleys, and Fig. 15 (b) is a side view of same. The part of the rope that passes from the right-hand groove of the pulley h_2, Fig. 14, passes to the left-hand groove of the pulley g_1, Fig. 15 (a). From this pulley the rope passes around the larger grooved pulley e_3, then back around g_1, then around e_4, then around g_1, until it finally passes over the grooved guide pulley h_1 to the carriage. The other part of the rope, which is in the left-hand groove of the pulley h_2, Fig. 14, passes to the right-hand groove of the pulley g_1, Fig. 15 (a), and then around the pulley e_4 in the same manner as the rope on the other side was passed around e_3, both parts of the rope emerging together over the pulley h_1 between the ropes passing from e_3 and e_4 to g_1.

Occasionally the rim band will fly from the pulleys, especially if it is run too slack. When replacing it, first be sure that it is crossed; then, commencing on the outside grooves of the pulley g_1 on the drawing-in shaft, pass the ropes around e_3, e_4, constantly working toward the center from each side until the ropes finally come together over the guide pulley h_1.

EASING-UP MOTION

24. The **easing-up motion** is in operation during the time which the accelerated speed is putting the twist into the yarn. When twist is put into yarn, the yarn grows shorter in length, or, as the effect is technically designated, the yarn *takes up*. Thus, while the accelerated speed is rapidly putting twist into the stretch of yarn, there must be some method of moving the carriage inward slightly, in order to accommodate the twist and ease the tension that the twist generates between the spindles and the delivery rolls. This necessary easing, or drawing in, of the carriage is performed by the easing-up motion, which, as shown in Figs. 6 and 7, derives its motion primarily from the drawing-out gear e_9, which in this case receives motion from the pulley e_4 that is fastened to the pulley e_5 but is loose on the shaft e; the motion is transmitted by means of the rim band h from the pulley e_4 to e_8. The gear e_9 through the gears e_{10}, e_{11}, e_{12}, and clutch

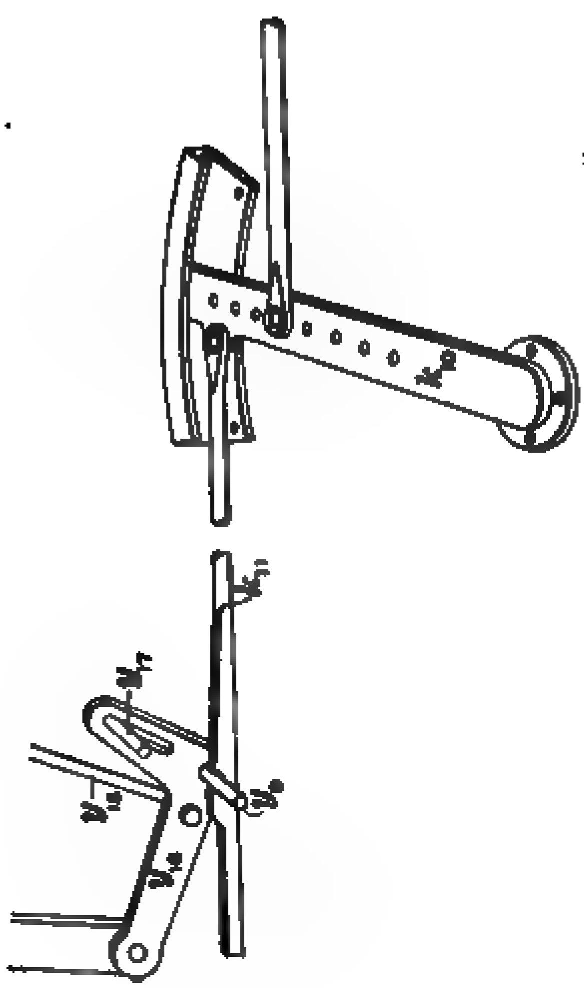


FIG. 16

e_{13}, e_{14} drives the shaft f, on which is fastened the worm k, which meshes with the worm-gear k_1, fast to the upright shaft k_2.

Referring to Fig. 16, the upper part k_3 of a clutch is keyed to the upright shaft k_2, but is movable on the shaft, so that it may be disengaged from the lower half k_4 when the easing-up motion is not in operation. A pinion k_5 that is fast to the lower half of the easing-up clutch meshes with a rack k_6. The two halves of the clutch are allowed to come in contact by the release of the yoke k_7 that controls k_3; this is effected by the removal of the support of the pin k_8 that is attached to the yoke, as will be explained later. The rack k_6 is connected with a rod k_9 that is connected with a lever k_{10} pivoted to the floor. Attached to the outer end of this lever is another rod k_{11}, which connects with the carriage by means of a slot in the rod, with which a pin y_2 attached to the carriage engages. This pin is lifted from the slot at the right time by a suitable mechanism. The object of the lever k_{10} is to furnish a ready method of changing the amount of easing up. The rod k_9 connecting with this lever may be inserted in any of the holes with which the lever is provided, so that any desired amount of motion may be imparted to the carriage. The amount of easing up necessary depends on the amount of twist that is put into the yarn, the most being necessary when the twist is greatest.

The motion is imparted to the carriage by the easing-up mechanism when the two halves of the easing-up clutch k_3, k_4 are in contact, in which case the pinion k_5 draws in the rack k_6 because of its rotation and, consequently, the carriage is also drawn in slightly.

BACKING-OFF MOTION

25. After the completion of the twisting motion, the actual spinning process is completed and it becomes necessary to wind the yarn on the bobbins or cops before another stretch can be spun. Before this can be done it is first necessary to reverse the direction of rotation of the spindles

Fig. 17

for a sufficient number of rotations to unwind the coils from the top of the bobbin, but not enough to run over and unwind any of the yarn spun and wound on the bobbin at the previous draw of the carriage. The reason for this unwinding is that, when the spinning process has been completed, a number of irregular coils remain around the top of the bobbin that must be removed before the winding of the bobbin can begin.

In order to reverse the direction of the spindles, the direction of the rim band must be reversed. This is accomplished by driving the band from the grooved friction pulley g_1, Figs. 6, 14, and 17, loose on the drawing-in shaft g. The inside of this pulley is made conical and forms one-half of a friction clutch. The power for the back-off motion originates from the second driven pulley e_2, which is fast to a sleeve that is loose on the main shaft.

Fast to the same sleeve as the pulley e_2 is the gear e_7, which drives the gear g_4 through the intermediates g_6, g_5. The gear g_4 is fast to a sleeve g_3 that is loose on the drawing-in shaft. On the other end of the sleeve is a friction cone g_2 that fits into the grooved friction pulley g_1. In Fig. 6, the back-off friction cone g_2 is not shown in contact, but when the sleeve g_3 is operated on by the back-off lever w, Fig. 17 (which fits into the groove in the sleeve), the friction cone is thrust into the friction pulley, thus transmitting the power from the second pulley e_2 on the main shaft to the grooved pulley g_1 and driving the rim band in the opposite direction. From this it will be seen that the rim band is driven by three agencies during the time in which it is turning the spindles; namely, the grooved pulleys e_6, e_8, g_1, which are driven respectively by the pulleys e_3, e_4, e_2.

At the same time that the backing off is taking place, the winding faller descends, in order to guide the yarn on the bobbin during the next operation—that of winding on. When the winding faller descends, the counter faller simultaneously ascends, in order to keep the tension on the yarn and prevent its kinking up into snarls. The mechanism of the fallers will be considered later, as will also the builder

rail, which governs the motion of the faller while guiding the yarn on the bobbin during the winding. It will be sufficient to say here that the winding faller descends quickly in order to make a hard bobbin and one that will unwind easily; it then ascends slowly until the carriage is drawn in.

DRAWING-IN MOTION

26. Leaving out all consideration of the fallers, it will be well to consider how the carriage is drawn in after the backing off and change of the fallers have taken place. The power for drawing in the carriage is derived from the second pulley e_2, Fig. 6, which imparts motion as explained in connection with the backing-off motion to the gear g_4 on the sleeve g_3. However, while the carriage is being drawn in, the backing-off friction cone is not in contact, but the sleeve g_3 is thrust in the other direction and one-half g_7 of the drawing-in clutch on the gear g_4 is in contact with the other portion g_8, which is fast to the drawing-in shaft g, thus imparting motion to the shaft when the belt is on the second pulley and the drawing-in clutch is in contact.

Referring to Fig. 17, which is a view of the headstock, showing the principal parts as seen from the front, or carriage side, of the mule, it will be seen that there are two scrolls g_9 and g_{10} fastened to the drawing-in shaft g. The drawing-in bands are attached to these scrolls and also to the carriage; thus, when motion is imparted to the gear g_4 and the drawing-in clutch is in contact, the scrolls will wind up the drawing-in bands and draw in the carriage.

The drawing-in scrolls have a different action from that of the draft scroll. With the draft scroll, it will be remembered that the band commences on the large diameter and, when imparting motion for the drawing-out of the carriage, is wound down on the small diameter. With the drawing-in scrolls the action is the reverse; the band is wound first on the small portion of the scroll, then on to the greatest diameter, when the carriage receives its greatest speed, and then on to a smaller diameter on the other side of the scroll.

The small diameter with which the scroll commences enables the heavy carriage to be started easily and afterwards moved more quickly, while the band running down again on to a small diameter enables the momentum of the carriage to be easily checked. Abruptness of action and the consequent strain on the bands and carriage are thus avoided and still the carriage is drawn in as rapidly as possible, the start and finish being slow. At the same time that the carriage is being drawn in, the spindles are being turned by a special device and are winding the y . on the bobbins.

27. Check-Band.—It will be seen that there is an extra scroll g_{11}, Figs. 6 and 17, attached to the drawing-in shaft. The band is wound on this scroll in the opposite direction to the bands on the drawing-in scrolls and is known as the **check-band.** The check-band is unwound from its scroll while the drawing-in bands are being wound up, and vice versa. The check-band passes over a binder pulley that is fixed in a slotted casting attached to the floor and is then attached to the mule carriage. The binder pulley may be moved in the slotted casting by means of a screw for adjusting its tension.

The object of the check-band is to exercise a drag and avoid overrunning the carriage, which may readily occur, owing to its high and variable speed, while it is being drawn in by the drawing-in scrolls and bands; that is, the drawing-in scrolls might, were it not for the check-band, give the carriage such a high velocity that the momentum would cause it to overrun itself and go in faster than the scrolls could wind up the drawing-in bands.

The check-band also prevents the carriage from *banging in*, as it is technically called, when the carriage stops with a shock at the end of the draw. To prevent this, the check-band requires delicate adjustment, in order that the carriage may work smoothly while being drawn in, and come gently against the back stops without any shock. The more tension placed on the check-band by screwing back the binder pulley around which it passes, the more gently the

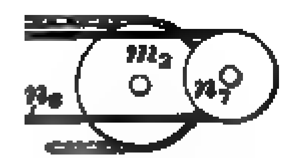


Fig. 18

carriage will come to a stop at the finish of the drawing-in; and, vice versa, the looser the band, the harder the carriage will bang in.

QUADRANT

28. At the same time that the carriage is being drawn in, the spindles are being turned so as to wind the stretch of yarn between the delivery roll and the spindle on to the bobbin as it is released by the inward run of the carriage. It will be readily seen that in order to wind a stretch of yarn that is of a constant length for each draw of the carriage the spindles must make more revolutions at the start, when the bobbins are empty, than when sufficient yarn has been wound on the bobbin to give it its full size. This is owing to the varying diameter, which is only that of the barrel of the bobbin at the start and larger when the base of the bobbin has attained its maximum diameter; that is, when the *cone*, shown by the dotted lines in Fig. 23 (*a*), has been built. Between these two points the number of revolutions of the spindle required to wind the stretch of yarn is constantly decreasing. This variable speed of the spindles renders it necessary that some device other than the rim band be used for turning the spindles during the drawing in of the carriage. This is accomplished by means of the **quadrant** and accompanying mechanism, shown in Fig. 18. The turning of the spindles for the winding on of the yarn during the drawing in is in reality performed by the motion of the carriage itself, which, pulling against the quadrant l, unwinds the quadrant chain l_1 from the drum l_2, thus of course producing a rotation of the drum l_2 on its shaft. Attached to l_2 is a gear l_3 that meshes

FIG. 19

with an intermediate gear l_{11}; this, in turn, meshes with the gear l_8 loose on the cylinder shaft c_{10}.

Referring to Fig. 19, which is a plan view of the drum l_4, the gear l_8 is fast to one-half l_9 of a clutch; both l_8 and l_9 are loose on the shaft c_{10}. The portion of the clutch marked l_9 is moved in contact with that portion marked l_{10}, which is fastened to c_{10}, immediately after the spindles have backed off and the carriage has started in. Thus, when the drum l_4, on which the quadrant chain l_3 is wound, is rotated, the motion is imparted to the drum c_4, Fig. 18, around which the spindle bands pass, thus imparting motion to the spindles.

The quadrant, as shown in Fig. 18, is driven by means of a chain m that is attached to the carriage. This chain passes around a pulley m_2 and then around the sprocket gear m_1, from which it is conveyed back to the carriage. Attached to the sprocket m_1 is a pinion gear m_3 that meshes into teeth m_4 cut on the inside of the circumference of the quadrant. By this mechanism the quadrant is revolved on its axis around the shaft l_{12}. Thus, when the carriage is drawn in, the quadrant turns toward the carriage. As the carriage comes out again, the quadrant recovers itself, because the chain m pulling over the pulley m_2 turns the sprocket m_1 in the opposite direction.

The quadrant chain l_3 is fastened to a casting l_6 attached to the floor and passes over a pulley l_2 attached to the quadrant before being wound on the chain drum l_4. The pulley l_2 is attached to a differential screw l_1 by means of a block, and by this means may be raised from a point nearly at the axis of the quadrant to a point outside its circumference. The entire quadrant is operated at each inward run of the carriage independently of the position of the pulley l_2.

Suppose that the pulley l_2 is at the bottom of the screw l_1, or *wound down;* then as the quadrant revolves, owing to the movement of the carriage, the position of l_2 will remain nearly the same, owing to its being practically at the axis of the quadrant. Under these conditions the spindles will receive the maximum number of turns, and the amount of the chain l_3 unwound from the drum l_4 will nearly equal the traverse of the carriage on its forward run.

Suppose, however, that the pulley l_2 is raised by means of the screw l_1 until it assumes the position shown in Fig. 18. In this case, the pulley will be carried forwards as the quadrant is turned by the carriage, owing to its being out of center in regard to its position on the quadrant, and less chain will be unwound from the drum l_4; consequently, there will be fewer revolutions of the spindles.

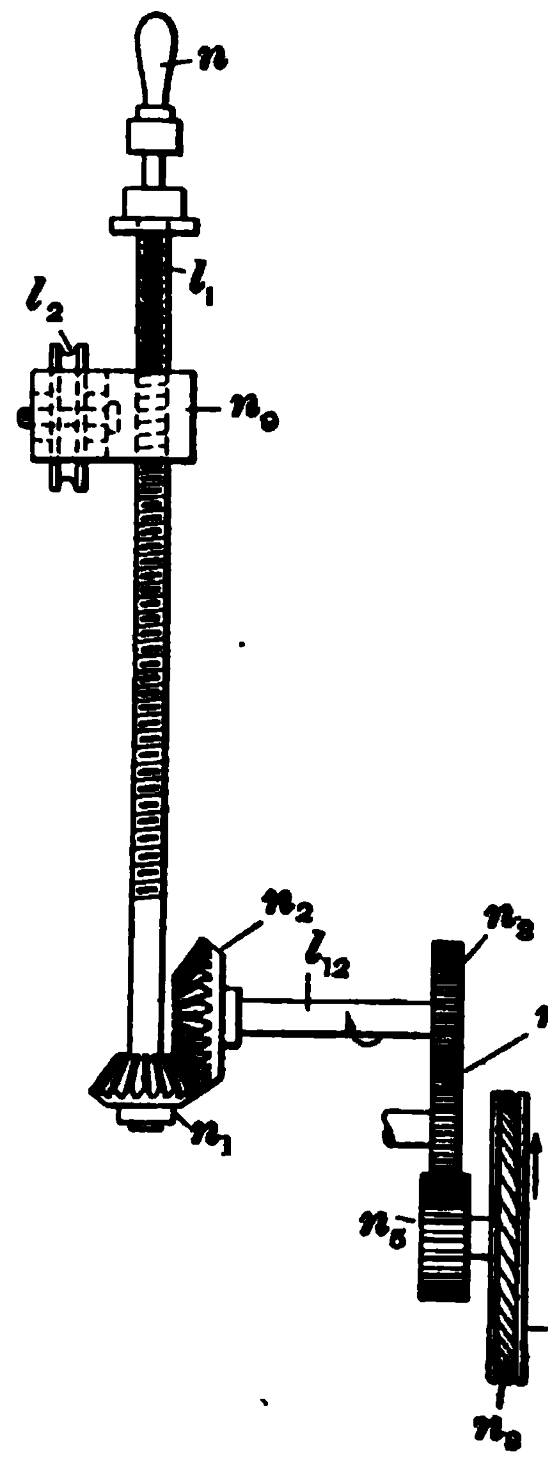


FIG. 20

After a full set of bobbins has been doffed from the mule, the pulley l_2 is wound down as far as possible on the screw l_1 by means of the crank-handle n so as to give the maximum number of turns to the spindle. As the winding of the yarn on the bobbin in building the base proceeds, the pulley l_2 is wound up on the screw l_1 in proportion to the increasing diameter of the bobbin.

29. Quadrant Regulator. The differential quadrant screw is turned by an automatic device that is regulated by the tension of the yarn. If the yarn becomes too tight, as it will if the spindles make too many revolutions, the quadrant screw is turned so that the pulley l_2 will be raised, thus reducing the turns of the spindles and consequently allowing the yarn to be slackened. The pulley l_2 turns in bearings in the block n_9, Fig. 20. Owing to the fact that the screw l_1 is differential, that is, has a constantly changing pitch, it would be impossible to have a thread cut in the block n_9 that would fit the screw at all places; the block therefore has a smooth hole through which the screw passes, having only a pin projecting into the thread of the screw. Attached to the bottom of the quadrant screw

is a bevel gear n_1 that meshes with a bevel gear n_2 fast to the shaft l_{12} on which the quadrant is centered. Attached to the same shaft is a gear n_3 that meshes with a gear n_4, this gear, in turn, meshing with a gear n_5. Fast to the same stud as this gear is a grooved pulley n_6.

The parts referred to are also shown in Fig. 18, where it will be seen that there is an endless feed-band n_8 passing around the pulley n_6 and also around a pulley n_7. This band passes directly beneath a casting n_{10} on the carriage, and an elbow lever n_{11}, known as a **grab lever**, is so arranged that under certain conditions it will pinch, or hold, the band against the casting n_{10}. The bite will only hold the band when the carriage is being drawn in. This mechanism does not move the quadrant pulley l_3 at each draw unless the tension of the yarn is such as to make it necessary. The band n_8 is not attached to the carriage; and if the grab lever n_{11} does not hold it against the carriage, there is no motion of the quadrant screw and pulley l_3.

The grab lever is controlled by the position of the fallers. Attached to the outer end of n_{11} is a rod n_{12}, at the top of which is a pulley n_{13}. Around this pulley a chain n_{14} passes and is attached to arms n_{15}, n_{16} fastened, respectively, to the faller shafts b_2, b_3. If the spindles revolve too fast, the yarn will become too tight during the winding as the carriage runs in; this will cause the counter faller b_3 to be lowered, and will allow the lever n_{11} to drop, which it will readily do, owing to its weighted end. The grab lever then assumes such a position that the band n_8, instead of passing freely between n_{11} and n_{10}, is gripped. The motion of the carriage on its inward run then pulls the band n_8 and imparts motion to the quadrant screw l_1 through the train of gears previously mentioned. The direction of this motion is such that its effect is to raise the roll l_3 around which the quadrant chain l_2 passes, thereby allowing less chain to be unwound and thus less turns of the spindles to be made, which will relieve the tension of the yarn by winding less yarn on the bobbin.

The device just explained only works until the base, or cone, of the bobbin is built, after which it takes the same

number of revolutions of the spindles for each draw in order to wind on the stretch of yarn. After the cone is built, the spinner usually turns over the end link of the chain n_{14} on the lever n_{16}, thus raising the lever n_{11} from all possible contact with the rope n_{8}, as if the pulley l_{9} is wound up to the top of the screw l_{1}, the band n_{9} is liable to be broken if caught by the lever n_{11}.

Fig. 21

The reason for having the quadrant pulley moved by a differential screw is that the motion is thus made proportional to the increasing amount of yarn wrapped around the bobbin as its diameter increases; that is, the thickness of a single layer of yarn around an empty bobbin will increase its diameter more, proportionally, than the same thickness when the cone of the bobbin is nearly built. The motion just described for controlling the position of the quadrant-chain

pulley is called the **quadrant regulator** and sometimes the **quadrant governor.**

The quadrant-regulating device shown in Fig. 18 is somewhat unreliable, since after the mule has been in operation for some time, the band n_9 will wear grooves in the grab lever n_{11} and projection n_{10}, so that its operation becomes uncertain, as the band n_9 cannot then be as securely gripped. Another defect of this arrangement is that a frayed place or splice in the band will sometimes cause the band to be held and the pulley l_2 raised when in reality there is no necessity for so doing.

A better device for accomplishing the same purpose as the grab lever is placed on the latest-model mules. As shown in Fig. 21, when this device is used the band n_9 is led around a binder pulley n_{17} and then around another pulley that has attached to it a 4-tooth ratchet n_{18}. The chain n_{14} that connects with the fallers governs the motion of a rod n_{19} that is free to rise and fall through a slotted casting n_{20}. During the ordinary running of the mule, the ratchet n_{18} is rotated as the carriage is drawn in, but should the tension of the yarn in winding become so tight as to cause the counter faller to be lowered so as to slacken the chain n_{14} and lower the rod n_{19}, the latter will engage one of the teeth of the ratchet n_{18}, checking its motion and causing the band n_9 to be moved with the carriage and wind up the quadrant pulley l_2, Fig. 18.

Many spinners do not rely on the quadrant regulator, but raise the quadrant pulley l_2 by hand while the bottom of the bobbin is being built, giving the crank n a turn now and then as the height of the counter faller and the tension of the yarn dictate.

30. Action of Quadrant After Cone is Built.—While the cone, or first part of the bobbin, is being built, the quadrant pulley is constantly rising, but when the bottom of the bobbin has attained its final diameter, the quadrant pulley has reached the limit of its upward movement. The quadrant, however, has another function in winding the yarn,

without reference to the building of the cone. The top of the bobbin is, of course, always cone-shaped, and the winding-faller wire, when the carriage is drawn in, first descends rapidly, and then rises slowly, being operated by the builder rail, which will be described later. Thus the yarn in being constantly shifted on the cone-shaped top of the bobbin is also being constantly wound on different diameters.

In order to accomplish this successfully, it is evident that the spindles must have a constantly increasing speed as the faller guides the yarn from the large diameter of the bobbin upwards to the nose, where the diameter diminishes to that of the shaft of the wooden bobbin or, if the yarn is being spun into cops, to the diameter of the spindle. This is accomplished by the throw of the quadrant as it moves forwards at each draw of the carriage, which in itself produces a variable speed of the spindles even when the position of the chain pulley on the quadrant is fixed.

When the quadrant pulley has been raised to the top of the quadrant screw and is stationary, there is a definite amount of chain unwound at each draw of the carriage and consequently a definite number of turns of the spindles. But, at the same time, the spindles have an accelerated speed in order to give them a greater number of turns at the finish of the draw when the faller is guiding the yarn on to the bobbin at its nose, where the diameter is smallest. The action of the quadrant itself is responsible for this, without the action of the quadrant screw.

The pulley on the quadrant, around which the quadrant chain passes, moves, in consequence of the motion of the quadrant, in the arc of a circle. This circular motion is composed of a lateral and a vertical motion; thus, as the quadrant pulley is moved while in the top part of its throw, the lateral motion, which is carrying it toward the carriage, allows a smaller amount of chain to be unwound from the chain drum than would be unwound if the quadrant were stationary, and, consequently, the spindles make a smaller number of turns.

As the quadrant continues to turn, the path of the quadrant pulley becomes more and more nearly at right angles to the

motion of the carriage during drawing in; thus, a greater amount of chain will be unwound and there will be more turns of the spindles. The speed of the spindles will therefore constantly change in accordance with the positions the faller may occupy relative to the cone of the bobbin.

After the chain has been unwound from the drum, there must be some mechanism for rewinding it before the next inward run of the carriage. This is performed by means of the rope l_7, shown in Figs. 18 and 19, which is wound on the drum l_4 in the opposite direction to that in which the chain l_8 is wound, so that it winds up as the chain is unwound. From the drum l_4 it passes over a guide pulley l_{13}, Fig. 18, and thence to the rear of the machine, where it is fastened and the weight l_{14}, Fig. 5, hung on it. After the carriage is drawn in, the clutch l_9, l_{10}, Fig. 19, is released, so that the drum l_4 is free to revolve independently. As the carriage is drawn out, the rope l_7 is unwound, turning the drum l_4 in the opposite direction to that in which it revolves during the inward run of the carriage, and winding up the chain l_8, as it is slackened by the outward movement, ready for the next inward run of the carriage.

The quadrant chain is thus kept wound on its drum at all times when the clutch l_9, l_{10} is out of contact.

BUILDER MOTION

31. The object of the **builder motion** is to build on the bobbin the yarn spun at each successive outward movement of the carriage. As the carriage is drawn in, the quadrant mechanism imparts the necessary movement of the spindles, and the builder motion guides the yarn on to the bobbin in such a manner as to produce a bobbin of the required shape and size. The guiding of the yarn on to the bobbin is performed entirely by the winding faller, the counter faller simply keeping the yarn at the required tension and preventing slack yarn, which would form kinks.

32. Builder Rail.—The position and motion of the winding faller, therefore, regulate the shape and size of

Fig 22

the bobbin, and in performing its function of guiding the yarn on to the bobbin it is controlled by the position and shape of a rail known as the **builder rail.** The mechanism of the builder motion is shown in Fig. 22, in which the carriage is represented as being drawn completely in to the delivery rolls and the fallers as having just resumed their positions clear of the yarn, as when the drawing-out mechanism is in operation. A short arm b_6 attached to the shaft b_2 of the winding faller b is connected with a bar, or lever, b_7, known as the *faller leg*. A small wheel p_2 known as the *builder-rail traveler* is carried in bearings in the end of a lever p_3 and runs on the surface of the builder rail p when motion is imparted to the carriage. In order that the builder-rail traveler shall not have any lateral movement that would tend to cause it to slip off the builder rail, a projection of the lever p_3 fits into a slot b_8. By means of this arrangement the builder-rail traveler is free to move in a vertical plane but in no other direction, except as it is carried forwards and backwards by the movement of the carriage.

A stud p_4 is fixed in the lever p_3, and during that period of time in which the carriage is being drawn in and the yarn guided on to the bobbin, this stud fits into the angle b_9 of the faller leg, thus supporting it and allowing any vertical motion of the builder-rail traveler to be imparted to it and, through the arm b_6, shaft b_2, and sickle b_1 to the winding-faller wire b. The faller leg is held firmly in contact with the stud p_4 not only by its own weight and the tension of the yarn, which tends to throw the winding faller upwards, but also by means of the springs b_{12}, not shown in Fig. 22 but shown in Figs. 4 and 31, that tend to turn the shaft b_2 in such a direction as to keep the faller leg constantly pressing downwards. From this description it will be seen that the shape of the builder rail p, Fig. 22, and its altitude govern the vertical movement of the builder-rail traveler p_2 as it rolls along the surface of the builder rail while the carriage is being drawn in, and that the position and movement of the winding-faller wire b are governed by the same agency. The movement of the winding faller, however, is in opposition

to that of the builder-rail traveler; that is, if the latter rises, the faller wire is depressed, while if the traveler is lowered the faller wire is raised.

The front part p_1 of the builder rail is inclined upwards for a short distance, while the main part p slopes backwards to the end of the inward run of the carriage, so that the traveler in moving over its surface first rises rapidly and then descends slowly, thus producing just the opposite effect on the faller wire; that is, the faller wire first descends rapidly and then rises slowly. Consequently, the yarn is first wound down on the bobbin in a series of coarsely pitched spirals and then wound up again in a series of finely pitched spirals. This method of winding each length of yarn formed at a single draw of the carriage gives the bobbin sufficient firmness to enable it to withstand all ordinary handling without unraveling or slubbing off at the nose.

The builder rail is composed of two parts p, p_1, the latter being in the form of a loose rail hinged to the rail proper. As the yarn is spun and wound on the bobbin it must constantly be wound higher and higher as the bobbin forms, and as this necessitates a corresponding movement of the winding faller, it is evident that as the formation of the bobbin proceeds the builder rail, since its movement is contrary to the movement of the faller wire, must be constantly lowered. This movement of the rail is obtained by means of the *shoes* p_5, p_6, p_7 on which it rests, the main part of the rail p being supported by the shoes p_5, p_6, and the loose rail p_1 by the shoe p_7. These shoes are all rigidly fastened together and when they are operated by the builder gears, which will be described later, they all move backwards in unison, thus lowering all parts of the builder rail. The motion of the shoes is intermittent, one movement taking place at each draw of the carriage; therefore, each stretch of yarn is wound on the bobbin in a slightly higher position than the previous stretch, thus accomplishing the building of the bobbin. When a new set of bobbins is started, the builder rail rests on the highest part of the shoes, but as the formation of the bobbin proceeds, the shoes are moved backwards and the rail lowered

until, when the bobbin is finished, it is resting on the lowest part of the shoes. On some mules the builder rail is made in one solid piece, that is, without the loose rail p_1, and since in this case only two shoes, one at each end of the rail, are necessary, it is known as a *two-shoe builder rail*, whereas the one shown in Fig. 22 is called a *three-shoe builder rail*. The object of the three-shoe builder rail is to furnish a convenient method of readily adjusting the rail to form differently shaped bobbins and to relieve the yarn of any undue strain during the winding.

33. The immediate object accomplished by the loose rail p_1 is the lengthening of the *chase* as the cone, or bottom part, of the bobbin is building. The term chase refers to the length of the vertical movement of the winding faller during the time that it is operated by the builder rail; that is, the chase is the distance on the bobbin occupied by a single layer of yarn. If the layer of yarn is wound on $1\frac{1}{4}$ inches of the length of the bobbin, the length of the chase is $1\frac{1}{4}$ inches, etc. The lengthening of the chase is due to the difference in the shape of the shoes p_6, p_7, and only takes place while the cone of the bobbin is being built. It will be noticed that for a short distance at the top, the shoe p_6 is inclined at a lesser angle than the shoe p_7; thus, as both shoes are moved backwards at the same speed, the end of the loose rail p_1 will be lowered faster than the main part of the rail p during the first part of the movement. The effect of this is to increase the inclination of the loose rail and therefore the length of the vertical movement of the builder-rail traveler, of the winding

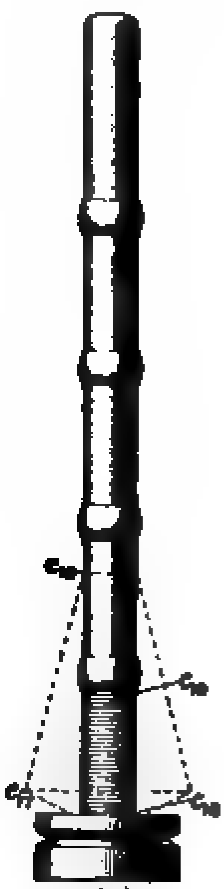


Fig. 23

faller, and the length of the chase. Thus, as shown in Fig. 23 (*a*), the first stretch of yarn will be wound on the bobbin between the points c_{15}, c_{16}, and as the builder rail is lowered, each succeeding layer will be wound on the bobbin slightly higher and the length of the chase also increased, until a layer c_{17}, c_{18} is formed. When this point is reached the shoes will have been moved backwards so that the builder rail is just commencing to move down the steeper part of the shoe p_9, Fig. 22, and the cone of the bobbin, shown by the dotted lines in Fig. 23 (*a*), will have been formed. From this point the slant of each shoe is the same; therefore, all parts of the builder rail will be lowered an equal distance at each draw of the carriage and the length of the vertical movement of the builder-rail traveler, of the winding faller, and the length of the chase will remain constant. Each successive stretch of yarn, however, because of the constant lowering of the builder rail, continues to be wound on the bobbin slightly higher than the previous stretch, until a full bobbin, as shown in Fig. 23 (*b*), is obtained.

As the builder rail is lowered it is guided by a slotted steadying bracket p_{10} with which a stud on the rail engages. The slot in this bracket slants in the opposite direction to the inclination of the shoes, so that as the rail is lowered it is thrown against the shoes, thus giving it greater stability and steadiness. The inclination of the slot also has the effect of moving the builder rail backwards in a horizontal direction as it is lowered, which will result in the rail being lowered somewhat more slowly than if a vertical slot were used; this backward motion of the rail will also increase the length of the short incline of the rail and shorten the long incline, because it will move the highest point of the rail nearer to the center of the movement of the carriage. This will result in the winding faller performing its downward motion at a slower rate of speed and its upward motion correspondingly quicker. This is beneficial, because as the bobbin is built higher there is less slack yarn caused by the backing-off motion unwinding the coils of yarn between the yarn already spun and the top of the spindle, on account

of the diminished distance for such coils to form, and consequently there is greater strain on the yarn during the initial, or downward, movement of the winding faller. Therefore, by causing this downward movement of the winding faller to become slower as the bobbin increases in size, this strain on the yarn during the initial movement of the winding faller is mitigated.

At the back end of the builder rail a casting p_{11} known as the *flip* is hinged, the loose end resting on a casting p_{12}. As the rail is lowered the flip becomes raised relative to the rail, since the end attached to the rail is lowered with it, while the other end, resting on the casting p_{12} remains stationary. As a result, the angle, or corner, of the flip becomes raised above the surface of the builder rail and as the carriage comes against the back stops, the builder-rail traveler strikes the projection thus formed, and imparts a sharp snap, or *flip*, to the winding faller. The effect of this is to wind a few turns of yarn down over the nose of the bobbin, thus making a firmer nose and preventing the yarn slubbing up the bobbin. As the bobbin increases in size the amount of this movement of the winding faller will be increased, because the greater the distance that the builder rail is lowered, the farther the flip projects above its surface. The pin supporting the back end of the builder rail on the shoe p_8, instead of being fixed in the rail, is attached to a casting p_9 that is fulcrumed at p_{10} and is adjustable by means of a setscrew. By this means it is possible to adjust the back end of the rail so that it will be higher or lower as may be desired. Raising the back end of the builder rail has the effect of shortening the length of the upward movement of the winding faller, and lowering it lengthens this movement, thus shortening or lengthening the taper of the bobbin.

34. Builder Gears.—The movement of the shoes that control the builder rail is imparted by means of the builder gears, of which Fig. 24 (*a*) is a front and Fig. 24 (*b*) a side view. A roll c_{11} is attached to a bracket fastened to the front of the carriage in such a position as to engage

Fig. 24

a lever p_{15} at each draw of the carriage. As the lever p_{15} is engaged by the roll c_{16} the chain p_{16} will raise an arm p_{17} that is loosely supported on the shaft of the screw p_{9}. In one end of the arm p_{17} is a stud p_{20} that carries a ratchet p_{19} compounded with a gear p_{22} that meshes with a gear p_{21} that is fastened to the shaft of the screw p_{9}. At the other end of the arm p_{17} is fastened a pawl p_{18} that engages with the ratchet p_{19}. As the arm p_{17} is raised (together with the ratchet p_{19} and gear p_{22}), in consequence of the roll c_{16} engaging the lever p_{15}, the gear p_{21} will be turned, because the teeth on the ratchet p_{19} are inclined in such a direction that the pawl p_{18} will prevent it and, consequently, the gear p_{22} from rotating. Since the gear p_{21} is fastened to the shaft of the screw p_{9}, this will impart a slight rotary motion to the screw, and as the latter is threaded in a casting p_{14} attached to the shoe p_{7}, the shoe will be moved backwards, allowing the builder rail to be lowered slightly.

The shoe p_7 has an extended base, to which the shoe p_8 is attached by means of an adjusting screw p_{10}; the shoe p_5, Fig. 22, is attached to the shoe p_7 by means of the rod p_6. Thus the motion of the screw p_9 is transmitted to each of the shoes, and the builder rail thereby lowered.

As the carriage is drawn in, the roll c_{12} is drawn away from the lever p_{15}, and in consequence the tension on the chain p_{16} is relieved and the arm p_{17} falls, because of the weight of the ratchet p_{19} and gear p_{20} at its extremity. As this takes place the gear p_{20} is turned and the pawl p_{18} takes up on the ratchet p_{19}, assuming a new position for moving the gear p_{21} at the next draw of the carriage. In order to prevent any movement of the shoes and builder rail other than that imparted by the correct working of the builder gears, the screw p_9 turns in a friction plug, or bushing, p_{27}, which causes the screw to turn with sufficient difficulty to prevent any movement from vibration or the shock of the builder-rail traveler on the rail when the faller leg is locked.

The distance that the builder gears fall when released by the inward run of the carriage is regulated by means of a table p_{22}, which is threaded on a fixed screw p_{23} and supports the weight of the arm p_{17} by means of an extension of the stud p_{28} on which the ratchet p_{19} and gear p_{20} are centered. The lower this table is adjusted on its screw support, the greater the number of teeth that the pawl p_{18} will take up in the ratchet p_{19} at each fall of the builder gears, and consequently the faster the builder rail will be lowered. The faster the builder rail is lowered, the greater the speed at which the winding faller will rise, and the faster the winding faller rises, the smaller in diameter will be the bobbin; hence, the table p_{22} furnishes a ready means of regulating the size of the bobbin. The higher this table is adjusted on the screw, the larger will be the diameter of the bobbin, since in this case the builder rail will be lowered at a slower speed and the corresponding speed of the winding faller in rising will allow more yarn to be placed on the bobbin. A check-nut p_{24} locks the table p_{22} in any desired position and prevents accidental changes in the size of the bobbins.

The diameter of the bobbin may also be changed by setting the roll c_{13} on the carriage in a higher or lower position. In the former case a larger bobbin will be made, since less motion will be imparted to the builder gears and rail, while in the latter case a smaller bobbin will be made, because the builder gears will be lifted higher and will consequently lower the builder rail to a greater extent.

35. It is not out of place in connection with the size of the bobbin to mention the factors governing its hardness or firmness of structure, since this element governs the diameter of the bobbin to a certain extent, in that a soft bobbin is of larger diameter than a hard one, in consequence of the individual layers of yarn not lying so closely together. The hardness of the bobbin may be regulated by means of the weights b_{10}, Figs. 4 and 31, which by their connection with the counter-faller shaft b_8 govern the force that the counter-faller wire b_9 exerts on the yarn, and consequently its tension during winding. If more weight is applied to the counter faller, a greater tension is produced on the yarn during winding; hence, a harder bobbin will be formed. These weights are made similar to the weights of a pair of scales, and as many may be used as will be necessary to produce a bobbin of the required hardness, provided that the strength of the yarn is sufficient to withstand the amount of tension necessary to produce a bobbin as firm as desired. As the number of weights used and the consequent tension of the yarn depends largely on the strength of the yarn, coarse yarn requires more tension than finer yarn. Sometimes when running out lots there will remain only two or three jack-spools to be spun, in which case the weight on the counter faller should be correspondingly decreased.

OPERATION OF THE MULE AS A WHOLE

36. So far only those mechanisms that deal with the essential operations of the mule have been considered, and nothing has been said of other mechanisms that enable the parts performing the different functions of the mule to be put in operation at certain periods, nor of those mechanisms by means of which one motion is discontinued in order that another may begin. The action of the mule will now be considered during a complete cycle of the movements of a single draw, commencing with the carriage drawn in with the spindles in close proximity to the delivery rolls and ending with the reengagement of the parts previous to the next draw of the carriage.

37. Shipper Lever.—The movement of the mule as a whole is controlled primarily by means of the shipper lever o, Fig. 25, which is fulcrumed on a stand bolted to the floor at the front of the machine. A sliding incline o_2 attached to the shipper lever by means of a rod o_1 controls the movement of the belt lever o_3 and, consequently, of the driving belt, the end of the belt lever being pressed against the incline by means of a spring o_5 that is attached to an arm o_4 of the belt lever, also shown in Fig. 17. By pushing in the upper end of the shipper lever o toward the carriage the incline o_2 will be drawn forwards, as shown in the illustration, throwing the belt on to the loose pulley e_1 and stopping the mule in whatever position the carriage is, without regard to what motion is in operation at that time. Drawing the upper end of the shipper in the opposite direction will have the opposite effect and, with one exception that will be noted later, will start the mule in operation without regard to the position of the carriage or other parts, so that the motion of the mule will commence at exactly that period of its complete action in which it was previously stopped.

STARTING OF MULE

38. As the mule is started, therefore, the shipper lever is pulled away from the carriage and the incline o_2 moved backwards, which will allow the spring o_5 to pull the belt

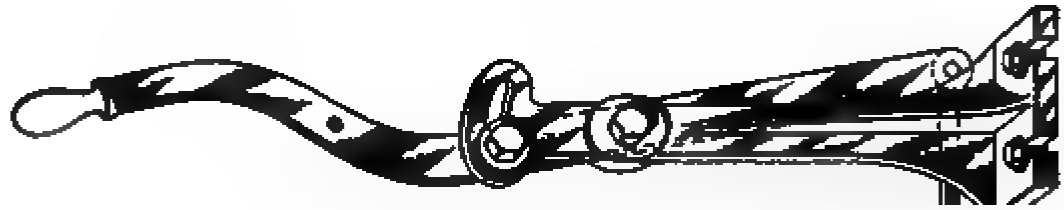


FIG. 25

lever o_3 over and thus throw the driving belt on to the driving pulleys. This movement of the belt lever is checked when the driving belt reaches the third pulley e_3 by an adjustable stop t_4, Fig. 27 (*a*) and (*b*), attached to the end of the lever t_3. The belt is moved over the pulley e_2, Fig. 25, but does not remain in contact with it for more than a fraction of a second; moreover, the pulley e_2 is virtually loose at this time, since neither the backing-off friction cone nor the drawing-in clutch are in contact, as the backing-off lever is in its neutral position. The motion of the driving belt, therefore, is at the start communicated to the third pulley e_3, which transmits the power to the draft scroll f_1, Figs. 6 and 17, the delivery rolls, and the smaller grooved rim-band pulley e_6. Thus three operations are commenced at the start—the carriage begins to recede from the delivery rolls, first slowly, by virtue of the dwell motion; the roving is delivered by the delivery rolls; and motion is imparted to the spindles.

39. Detent Mechanism.—The one instance in which the mule will not be started if the shipper handle is pulled away from the carriage is when the **detent mechanism**, shown in Figs. 25 and 27 (*a*) and (*b*), is unlocked. A lever q in which is fixed a stud q_1 tends to be forced forwards by a coil spring q_2, but may be locked back by means of a detent catch q_3 that engages with the stud q_1 whenever the lever is forced backwards far enough to allow this catch to drop over the stud. When, however, the detent catch q_3 is unlocked and the lever q is in its forward position, as shown in Fig. 25, its lower end is directly above a casting o_5 bolted to the arm o_4 of the belt lever, making it impossible for the mule to be started, because the casting o_5 will come in contact with the lower end of the lever q and prevent the arm o_4 from rising high enough to allow the belt to be shipped to the third pulley e_3. When, however, the lever q is moved backwards and the stud q_1 locked by the detent catch q_3, the lower end of the lever will be back far enough so that the casting o_5 will escape it and the belt lever be free to move the belt to the third pulley e_3 and also the fourth pulley e_4, if desired.

The lever q is locked by means of a movable wedge q_4, Fig. 25, on the carriage that is operated by a sliding rod q_5 on the front of the carriage, through the lever q_6, the shaft q_7, and the lever q_8. The wedge q_4 comes in contact with an adjustable setscrew in the lever q and if the rod q_5 is moved in the direction of the arrow, will assume such a position as to force back the lever q and allow it to becme locked. It will be seen, therefore, that when the carriage is drawn in, if it is desired to start the mule, not only must the shipper lever o be drawn forwards, but the rod q_5 must also be moved in the direction of the arrow, or to the left of the spinner.

The object of this detent mechanism is to allow the spinner to stop the mule at the end of any draw—that is, when the carriage is drawn in—from any position in which he may be. For instance, if he was at one end of a long mule and desired to stop the carriage in order to piece up several broken ends, or to place a new spool of roving in the mule, it would be very inconvenient to accomplish this with the shipper lever, as this would be 25 or 30 feet away. It should be particularly noted that the rod q_5 if moved to the right of the spinner, or in a direction opposite to the arrow, will stop the mule only when the carriage has been drawn completely in; that is, the mule will continue in operation and complete the draw, but will stop at the end of its inward motion. While the mule is running, therefore, the rod q_5 must be kept to the limit of its movement in the direction of the arrow, so that the wedge q_4 will be in position to lock the lever q each time that the carriage comes in, as otherwise the mule will stop. The lever q is unlocked at every draw of the carriage by means of a projection u_1 attached to the twist slide—a mechanism that will be described presently—which, when the twist slide drops, strikes an adjustable setscrew in the detent catch q_2, thus freeing the stud q_1 and lever q. Thus, if the wedge q_4 is not in position to lock the lever q again, the carriage must stop.

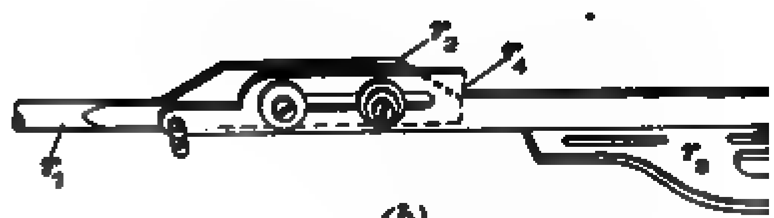
40. Roving Stop-Motion.—With the belt on the third pulley e_3, the roving motion, drawing-out motion, and rim band continue in operation without change until the requisite

length of roving is delivered, whereupon the delivery rolls are stopped by the roving stop-motion, while the motions of the carriage and rim band still continue.

DISCONNECTION OF DRAWING-OUT MOTION

41. Disengagement of Drawing-Out Clutch.—The next change that takes place is the checking of the outward movement of the carriage. When the carriage is drawn out until the spindles are 72 inches, or about that distance, from the delivery rolls, a bunter on the carriage comes in contact with a lever r, Fig. 26 (*a*), forcing its upper end forwards and moving the rod r_1 attached to its lower end backwards. At the other end of the rod r_1 is a wedge r_2 that slides in a slot in the draft slide r_3, as shown in detail in Fig 26 (*b*). As the wedge r_2 is forced backwards it raises from a notch r_4, Fig. 26 (*a*), in the draft slide a stud s_4 that is attached by a lever s_3 to a rod s known as the *latch rod.* As this takes place the draft slide is drawn forcibly backwards by a spring r_7 attached to it and to the stand r_{14}, its motion being checked when it has moved the proper distance by a casting r_8 against which it strikes. The draft slide is cast with a recess r_8 in one end [see Fig. 26 (*b*)], which, together with the wedge-shaped end r_6, serves as a guide for the lower end of the lever r_{10}. The upper end of this lever r_{10} is fitted with a yoke to operate the movable half e_{14} of the toothed drawing-out clutch, also shown in Fig. 17. As the draft slide is drawn backwards, therefore, the lower end of the lever r_{10} is forced into the recess r_8 in the slide, and its upper end disengages the drawing-out clutch e_{14}, thus checking the outward movement of the carriage. A spring r_{11} keeps the drawing-out clutch in contact when the lever r_{10} does not hold e_{14} away from e_{13}.

42. Easing-Up Motion.—At the same time that the drawing-out motion is disengaged, that is, when the draft slide is released, the easing-up motion is put in operation. This is accomplished by means of a raised place r_{13} on the edge of the draft slide, on which rests the stud k_8 that holds



(b)

Fig 28

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

the easing-up clutch k_3 out of contact when the easing-up motion is not in operation. As the draft slide is released, this raised edge r_{13} moves out from under the stud k_9, thus allowing the part k_3 of the easing-up clutch to drop in contact with k_4, Figs. 16 and 17, and the carriage to be eased up.

It will be noted that as the carriage is drawn out, the stud y_9 drops into the notch in the rod k_{11} and thus replaces the rods and consequently the rack k_8 in their initial positions.

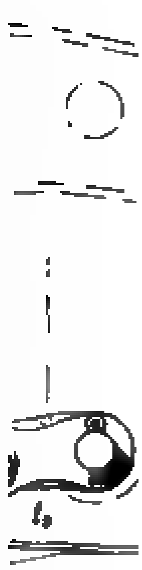
43. Accelerated Speed.—At the same time that the easing-up motion is in operation the spindles are being driven at the accelerated speed, which necessitates that the belt be shifted to the fourth driven pulley e_4, Fig. 6, in order that the large grooved pulley e_8 may drive the rim band. This is accomplished at about the time that the carriage reaches the end of its outward movement, in the following manner: When the belt is on the third pulley, the arm o_4, Fig. 27, of the belt lever rests against the stop t_4 on the lever t_3. As the carriage is being drawn out, motion is imparted to the drawing-in shaft g by reason of the drawing-in bands being unwound from their scrolls; in consequence, motion is imparted to the gear g_{13}, which is fast to the drawing-in shaft, and transmitted to the gear t, which meshes with g_{13}. On the back of the gear t is a projection t_1 that as the gear rotates comes in contact with an adjustable setscrew in the end of the lever t_3, thus forcing the lower end of the lever t_3 outwards, against the pressure of a flat spring t_5, and releasing the arm o_4 of the belt lever. When this release takes place, the spring o_8 will pull the arm o_4 upwards until it is stopped by an adjustable **T** piece u_3, thus shipping the driving belt to the fourth pulley e_4.

DROPPING OF THE TWIST SLIDE

44. The Twist Slide.—The accelerated speed continues to put twist into the yarn until it is checked by the dropping of the twist, which is accomplished by means of the mechanism shown in Fig. 27 (*a*) and (*b*). The gear e_9, which is attached to the main shaft e of the headstock, drives a gear x_1

(a)

Fig 27



(b)

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fastened to a short cross-shaft x, to which is fixed a worm x_1 that imparts motion to the twist-pin gear v; this gear is loose on a stud fixed in the twist slide u, which is simply a casting free to fall in a vertical direction through a limited distance unless locked. The stud that supports the twist-pin gear v also carries a lock-plate v_2 and a cover-plate v_3, both of which are loose on the stud. The lock-plate has a projection v_6 that rests on a casting x_2 bolted to the framework of the mule, and in this manner holds the twist slide u in a raised position so that the pin gear v will mesh with the worm x_1. In addition, the stud on which the lock-plate is supported carries a knock-off v_7 that is supported between two pins v_8, v_9 on the lock-plate in such a position as to be engaged by the pin v_1, which may be placed in any one of the holes with which the twist gear v is provided. As motion is imparted to the twist-pin gear, the lock-plate remains stationary until the pin v_1 comes in contact with v_7, whereupon the lock-plate will be moved, against the tension of a spring v_{10}, sufficiently to allow the projection v_6 to slip off the casting x_2 and a strong spring u_1 to pull the twist slide u and all parts connected with it to a lower position, thus among other results allowing the twist gear to become clear of the worm x_1.

During the time that the gear v has been turning it has been imparting motion to the cover-plate by means of a pin v_5 that engages a projection v_4 cast on the inside of the plate; this motion of the cover-plate winds up a weight v_{12} that is attached to it by means of a leather strap v_{11}. When the twist gear is removed from contact with its driving worm, the weight v_{12} turns the plate v_3 and, consequently, the gear v in the opposite direction until the pin v_5 comes in contact with v_7, thus resetting the twist-pin gear in its initial position. The lock-plate is returned to its initial position by the spring v_{10}, the projection on the lock-plate engaging with the casting x_2 immediately that it is raised above it.

45. With the dropping of the twist several changes are made in the action of the mule, the immediate result being the stopping of the accelerated speed and the commencement

of the backing off of the spindles. As the twist slide u is drawn down by the spring u_1, the **T** piece u_2 that is threaded in an extended arm of the slide casting forces down the arm o_4 of the belt lever until the driving belt is carried from the fourth to the second driven pulley. In order that the arm o_4 shall be carried down just far enough to bring the belt to this pulley, an adjustable setscrew u_3 is threaded into another extended arm of the slide casting u and by striking against a stop on the framework of the mule governs the extent of the fall of the twist slide and, consequently, the length of movement of the **T** piece u_2.

As the arm o_4 is carried below the stop t_4 on the lever t_3, the spring t_5 swings the lever t_3 to the right to its original position at the beginning of the drawing-out motion ready to receive the arm o_4 again when the belt is shipped to the third pulley at the next draw of the carriage.

46. As the pin v_1 in the twist gear controls the dropping of the twist slide, it also controls the checking of the accelerated speed and, consequently, the amount of twist placed in the yarn. By moving v_1 away from v_7 more twist will be placed in the yarn, while setting the pin forwards will have the opposite effect. It might be thought that instead of the knock-off v_7 that is carried loosely on the stud and secured to the lock-plate v_6 by the pins v_8, v_9, a simple projection on the lock-plate would serve to unlock the twist slide. This arrangement, however, has a special purpose in that it allows the pin gear v to make more than a single revolution if it is desired to place a greater amount of twist in the yarn than can be obtained in the ordinary way. This extra amount of twist is obtained by removing one of the pins v_8, v_9 that support the knock-off v_7; suppose, for instance, that the pin v_9 is taken out. When the twist gear v is reset by the weight v_{12}, it will be rotated until the pin v_1 strikes the knock-off v_7 and forces it against the right-hand side of the pin v_8. Ordinarily the twist gear v revolves while the twist is being placed in the yarn until the pin v_1 strikes the knock-off v_7 so as to turn the lock-plate v_6 and disengage

the projection v_8 from the casting x_3, which allows the twist slide u to drop; but in this case since the pin v_8 is removed, no support is given v_7 to accomplish this result until v_1 has pushed it around one complete revolution and forced it against the left-hand side of the pin v_8. The twist gear therefore makes one complete revolution before the twist slide drops, in addition to the number of holes that the pin v_1 is set. This, consequently, gives an adjustment whereby the amount of twist in the yarn can be greatly increased or even doubled if so desired. For instance, suppose that 70 holes of twist are wanted and the twist gear contains only 50 holes; then all that is necessary is to set the pin v_1 for 20 holes and remove the pin v_8, which will give 20 holes plus one revolution of the twist gear (50 holes) or 70 holes of twist. The number of holes of twist required by yarns of different sizes varies, and it may be generally stated that coarse yarn requires fewer holes of twist than finer yarn. Much also depends on the stock, as yarn made from poor and weak stock naturally requires a greater amount of twist to give it sufficient strength to withstand the weaving operation. Warp yarn also is generally harder twisted than filling yarn.

47. Engagement of Backing-Off Motion.—When the belt has been shipped to the second driven pulley e_2, Fig. 6, by the dropping of the twist slide, the power is transmitted through gears e_7, g_6, g_5, g_4, and sleeve g_3, Figs. 6 and 17, to the backing-off friction cone g_2. As the twist slide falls, another extended portion u_6, Fig. 27 (a), of the slide casting, which has previously held the back-off lever w in its neutral position, is lowered so as to pass from contact with an adjustable **T** piece w_1 threaded in the end of the back-off lever. The back-off lever, being now free to move, is drawn forcibly over by a spring s_6, Figs. 26 and 32, putting the back-off friction cone g_2, Figs. 6 and 17, in contact with the grooved friction pulley g_1. The rim band is then driven slowly in the opposite direction by the pulley g_1, so that the spindles, also being turned in the opposite direction, will unwind the coils of yarn between the top of the bobbin and

the yarn already wound on it, thus preparing for winding the stretch of yarn on the bobbin.

48. Unlocking of Detent Catch.—Another function performed by the falling of the twist slide is the unlocking of the detent catch q_2, Figs. 25 and 27, which makes it impossible for the arm o_4 to rise sufficiently to ship the belt to the third pulley and thus draw the carriage out again, unless the wedge q_4, Fig. 25, is in a position to lock the detent catch when the carriage comes in. This is accomplished by the projection u_3 that comes in contact with the adjustable setscrew in the end of the detent catch q_2, thus raising it from the stud q_1 in the detent lever q.

It will be understood that all of the various functions performed by the dropping of the twist occur simultaneously with the fall of the twist slide and not in consecutive order as it is necessary to describe them.

BACKING OFF

49. Changing of Fallers.—As the backing-off motion is put in operation and the center shaft of the carriage thereby reversed, the fallers are changed so as to assume a position for winding the yarn on to the bobbin.

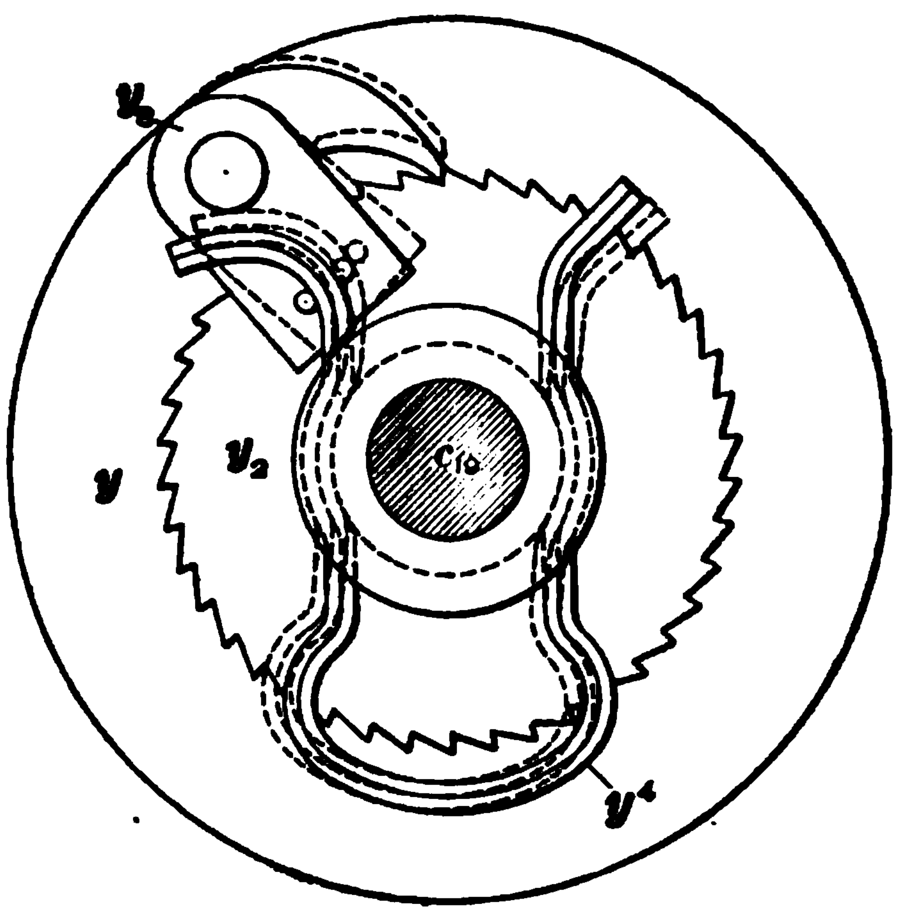


Fig. 28

A ratchet y_2, shown in Figs. 22, 29, and 30, and in detail in Fig. 28, is fast to the center shaft c_{10} of the carriage and is provided with an extended hub, around which a leather-lined steel clipper spring y_4 is placed. One end of this spring is extended between two pins in a pawl y_3 attached to a flange y loose on the shaft c_{10}. While the shaft c_{10} is being driven in the

ordinary direction, shown by the arrow in Fig. 29, the pressure of the spring y_4 on the pawl y_3 is such as to keep the pawl out of contact with the ratchet y_2, but immediately that the backing-off motion starts in operation and the direction of rotation of the shaft c_{10} is thereby reversed, the pressure of the spring y_4 will be in the opposite direction, and the pawl y_3 will be thrown in contact with the teeth of the ratchet gear, which will therefore impart motion to the flange y, since the pawl is attached to the flange. This flange forms part of a drum y_1, which is loose on the shaft and has attached to it a chain y_5 known as the *back-off chain*, the other end of which is attached to a segment b_{11} fastened to the winding-faller shaft b_9. As motion is imparted to the drum y_1 the chain y_5 is tightened and the shaft b_9 of the winding faller turned until the faller leg b_7, Fig. 22, rises so that it will slip over the stud p_4; this is accomplished by means of a strong spring y_{10} attached to a lever y_{12}, to which the faller leg is connected by means of a connecting-rod y_{11}. The winding faller b is therefore lowered so that it will assume the correct position for winding the stretch of yarn, which of course is governed by the position of the builder rail, through the traveler p_3 and faller leg b_7.

Fig. 29

At the same time that the winding faller descends, the counter faller must ascend, in order to keep the proper

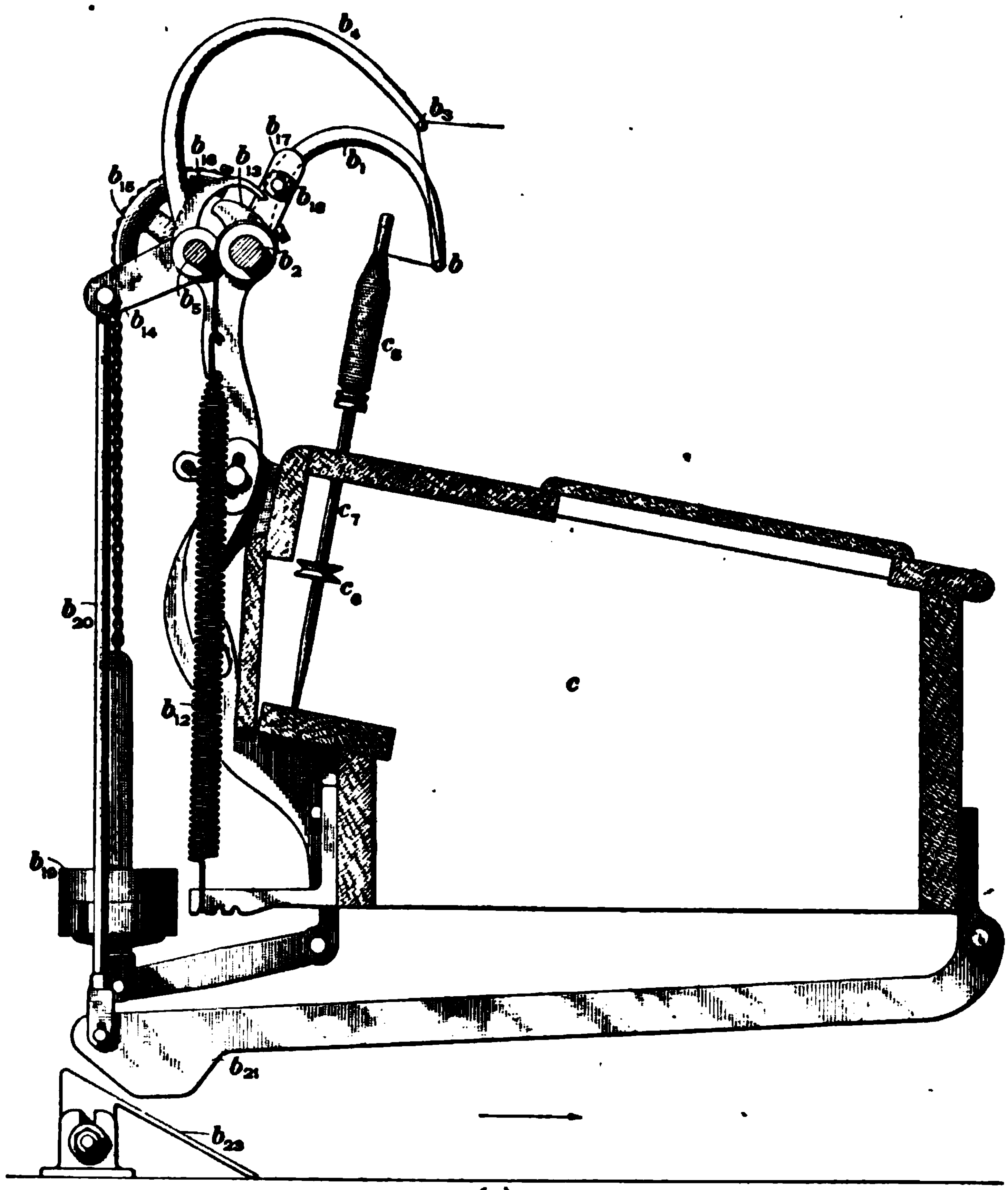
tension on the yarn and prevent the formation of kinks. The mechanism allowing this to be accomplished is shown in Fig. 31 (*a*) and (*b*). While the carriage is being drawn out and until the backing-off motion changes the fallers, they are locked as shown in Fig. 31 (*b*), so that neither faller wire is in contact with the yarn, leaving the spindles free to perform their function of drafting and twisting the roving into yarn. The winding faller b is held above the stretch of yarn by means of a spring b_{18} that is attached to the shaft b_1 of the faller by a leather strap in such a manner

FIG. 30

as to give the faller wire a constant tendency to move upwards. The height to which the winding faller rises is limited by a stop b_{13} that is setscrewed to its shaft b_1 and rests on the top of the counter-faller shaft b_3 when the winding faller b is in its highest position. The counter faller b_2 also has a tendency to be raised, because of the pull exerted by the weights b_{19} on the segment b_{18} which is attached to the counter-faller shaft b_3. Previous to the change of fallers by the backing-off mechanism, however, the counter faller is locked just below the top of the spindles by a locking finger b_{10}, which is fastened to the counter-faller

shaft b_2 and is prevented from rising by a roll b_{18} supported by a casting b_{17} fastened to the shaft b_2 of the winding faller.

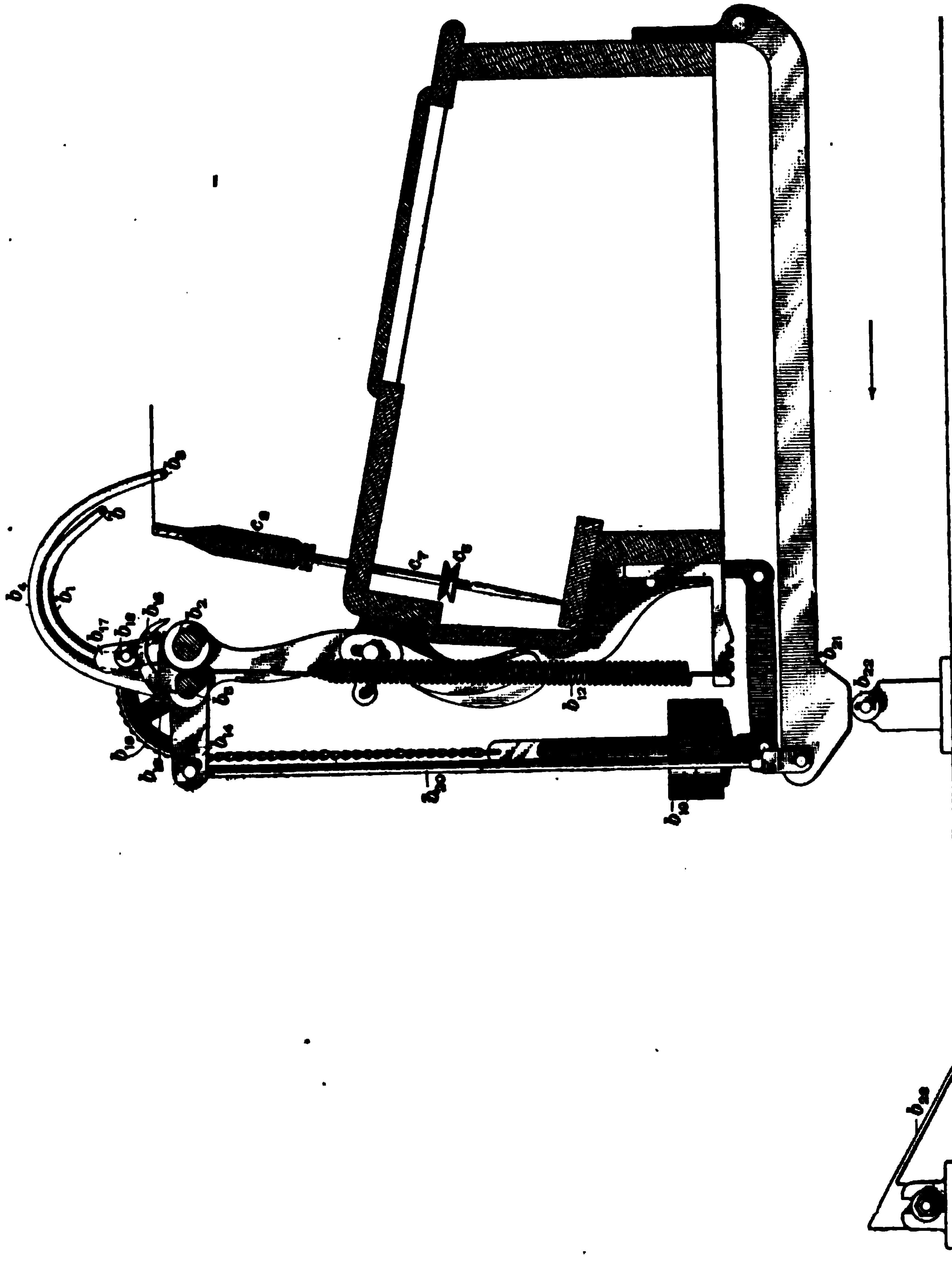
When the winding-faller shaft is operated by the tightening of the back-off chain, the fallers assume the position shown



(a)

FIG. 31

in Fig. 31 (*a*). As the winding-faller shaft is turned to lower the winding faller and lock the faller leg, the roll b_{18} is moved from the locking finger b_{16}, thus unlocking the counter faller and allowing the weights b_{19} to raise it into a position that is governed only by the tension of the yarn.



(b)

FIG. 31

There is a tendency for the counter faller when unlocked to rise too abruptly and with considerable force, and since this is liable to strain the yarn and break the ends, its initial upward movement is checked by an incline b_{23} bolted to the floor in such a position that when the fallers change, it will be directly under a lever b_{21} connected to the counter faller by a rod b_{20} and casting b_{14}, which is setscrewed to the counter-faller shaft. As the fallers change and the counter faller rises, the lever b_{21} will fall on the incline, which will thus support the weights b_{19} and prevent any further upward movement of the faller wire. As the carriage is drawn in the lever b_{21} will slide down the incline b_{23} until the tension of the yarn on the counter faller becomes sufficient to support the weights b_{19}.

50. Disconnection of Easing-Up Motion.—In addition to its other functions, the movement of the square shaft y_9, Figs. 22, 29, and 30, known as the *rocker-shaft*, also disconnects the easing-up motion. As the mule backs off and the rocker-shaft is turned by the action of the spring y_{12} it will raise the connecting-rod y_{13}, which will also raise a lever y_{16} fulcrumed on a casting bolted to and extending below the bottom of the carriage. The stud y_8 [see also Figs. 16 and 26 (a)], which is fastened in the lever y_{16}, by engaging with the notch in the easing-up rod k_{11}, communicates the easing-up motion to the carriage. As the lever y_{16} is raised, however, this stud is withdrawn from the notch in the easing-up rod k_{11}, and the easing up of the carriage thereby discontinued.

51. Engagement of Winding Clutch.—Still another function performed by the backing off is the putting-in gear of the winding clutch, by means of which the quadrant mechanism imparts motion to the spindle-band cylinder. Referring to Fig. 22, it will be seen that as the back-off chain y_5 raises the faller leg b_7 so that it will slip over the stud p_4, motion will be imparted to the rocker-shaft by the spring y_{12} as it pulls the lever y_{10} toward the back of the carriage. The result of this is that the lever y_{13}, which

is also attached to the rocker-shaft, will be moved toward the front of the carriage. As this takes place, a rod y_{14} that is passed through a hole in a casting attached to the upper end of the lever y_{13} and held in position by a spring y_{20} and collar y_{22} will also be drawn toward the front of the carriage, thus operating the lever y_{21}, Figs. 29 and 30, to which it is attached, and throwing the part l_6 of the winding clutch in contact with l_{10}. With the clutch in contact, motion will be imparted to the spindles as the carriage runs in, by the quadrant chain. A chain y_{19} attached to the drum y extends through a hole in a girt and has a weight y_{10}, Fig. 22, attached to its extremity. The object of this is to keep the drum in position and the slack out of the chain y_8 when the pawl y_3 is disengaged from the ratchet y_2.

It will be understood that all of the movements depending on the backing-off motion take place simultaneously with the tightening of the back-off chain as the spindles are reversed, and occupy but a comparatively short period of time.

DRAWING IN

52. As the carriage is now ready to be drawn in, the backing-off motion is discontinued and the drawing-in motion put into operation, as follows: The movement of the stud y_6, Fig. 26 (*a*), in being lifted from the notch in the easing-up rod k_{11} is great enough to allow the stud to strike and raise the latch rod s, thus unlatching it from the casting s_7, which has previously held it in a forward position. As the latch rod is released, a strong spring s_6 pulls it forcibly backwards, and a casting s_1 setscrewed to it comes in contact with the back-off lever w; this moves the back-off friction cone g_3, Figs. 6, 17, and 32, from contact with the pulley g_1, thus stopping the backing off of the spindles, and also throws the half g_7 of the drawing-in clutch in contact with g_6, putting the drawing-in motion in operation. The back-off lever is prevented from moving in this direction until after the twist slide has fallen and pushed down the catch t_7, which until this occurs is held in the position shown in Fig. 27 (*a*) by

the flat spring t_6. When the twist slide falls, however, a stud u_7 fastened to it strikes a lever t_8 and thus releases the catch t_7 which is fastened to this lever. This is a safety device that prevents the drawing-in motion from being accidentally put in operation at the same time that the drawing-out motion is working, which it will be understood would cause a serious smash.

When the latch rod has been drawn back and the casting s_1 has forced the backing-off lever over so that the drawing-in motion is in operation, the lever is locked in this position by means of a catch w_6, Fig. 32. This catch, which forms one

FIG. 32

arm of an elbow lever w_5, is held in a raised position by a spring w_7, so that it engages a projection w_4 of the back-off lever when the latter is forced backwards, which of course is against the tension of the spring s_8. This locks the back-off lever with the drawing-in motion in operation.

The adjustable stud y_{17}, Fig. 26 (a), in the lever y_{16} is simply a safety stud that rests just above the latch rod s and thus prevents its becoming unlatched until the mule backs off and the lever y_{16} is raised, since a smash would occur if the latch rod should accidentally be unlatched.

53. Locking of Twist Slide.—While the carriage is being drawn in several mechanisms are replaced in their

initial positions preliminary to the next draw of the carriage. The twist slide is raised by means of the roll t_1, Fig. 27 (a), on the gear t. This gear is of course now turned, by the gear g_{18}, in the opposite direction to that in which it revolved while the drawing-in shaft was receiving motion from the unwinding of the drawing-in bands during the drawing out of the carriage. As the gear t is revolved the roll t_1 comes in contact with an adjustable casting u_4 on the twist slide u and thus raises the slide to its original position. Although the **T** piece u_3 is raised with the twist slide, the arm o_4 of the belt lever will be prevented from changing its position by the detent lever q (see also Fig. 25), which was unlocked at the dropping of the twist. As the twist slide is lifted it raises the twist-pin gear v, so that it will again mesh with the worm x_9, although no motion will be imparted to it until the gear e_9 is again revolved by the driving belt being shipped to the drawing-out pulley. The twist is locked in position by the projection v_9 of the lock-plate v_8, which is returned to its position on the casting x_3 by the spring v_{10}.

54. Replacing of Latch Rod and Draft Slide. When the carriage has been drawn about half way in, the latch rod and draft slide are moved forwards and locked in the following manner: As previously described, the draft slide r_3, Fig. 26, was drawn backwards by the spring r_7 when the stud s_4 was raised by the movement of the rod r_1 and wedge r_2 that results from the pressure of the carriage on the bunter r at the completion of the drawing-out motion. As soon as the easing-up motion is put in operation the pressure on r is removed. This allows a spring r_6 to pull the rod r_1 and wedge r_2 forwards so that the recess r_4 will be clear to receive the stud s_4. Then as the latch rod is unlatched by the upward movement of the stud y_9 and drawn back by the spring s_6, the stud s_4 is carried back into the recess r_4 in the draft slide. Any forward movement now imparted to the latch rod will also move the draft slide to its initial forward position. This movement of the latch rod is obtained from a roll g_{14} attached to a gear g_{13} that is driven

from a gear g_{12} fastened to the drawing-in shaft. As the gear g_{13} rotates, the roll g_{14} engages with a casting s_2 setscrewed to the latch rod, which is thereby forced forwards, together with the draft slide, until it latches on the casting s_7, so as to be held forwards.

It might be thought that replacing the draft slide would allow the spring r_{12} to pull the lever r_{10} over and throw the drawing-out clutch e_{14} in contact; this is not so, however, since as the draft slide is replaced, the lever r_{10} is held by a long-headed screw r_{11} attached to it, that when the drawing-in motion is in operation extends behind a casting w_8, Figs. 26 and 32, setscrewed to the back-off lever w, which of course is then locked in such a position that the casting will be far enough backwards to accomplish this. This long-headed screw r_{11} is also a safety device, since it will not permit the drawing-out clutch to lock until the drawing-in clutch disengages. As the draft-slide is replaced the stud k_8 is lifted on the raised part r_{13} of the draft slide. This raises the upper part k_3 of the easing-up clutch from the lower part, in which position it remains until the draft slide is again released and drawn back by the spring r_7 at the end of the next outward run of the carriage.

REENGAGEMENT

55. Disengagement of Drawing-In Motion.—As the carriage reaches the end of its inward run the several parts are reengaged for the next draw, but first of all the drawing-in motion must be disconnected. This is accomplished by means of the lever w_8, Fig. 32, which is struck and forced back by a bunter on the carriage. As this happens the arm w_6 is lowered and the back-off lever released, whereupon the spring s_8 draws it over and throws the drawing-in clutch out of contact, moving the back-off lever until the T piece w_1, Fig. 27 (*a*), strikes u_6. As this movement takes place the catch t_7 is raised by the spring t_8 and thus locks the back-off lever so that the drawing-in motion cannot go into operation until the twist slide drops again; as it is also

prevented by u_4 from moving in the opposite direction so that the backing-off friction cone will engage, it occupies what is termed the *neutral* position.

In order to make the disengagement of the drawing-in motion positive, so that there will be no liability of a smash should the spring s_3 fail to operate the back-off lever, a lever w_6, Fig. 32, is placed in such a position that it is struck at one end by the lever w_4 as the latter is forced back by the bunter on the carriage. The other end of the lever w_6 engages with a projection w_5 on the back-off lever, so that the drawing-in motion is disconnected in any case when the carriage strikes the lever w_6.

56. Engagement of Drawing-Out Motion.—When the drawing-in is discontinued, the drawing-out motion is put in operation, so as to move out the carriage for the next draw, as follows: When the spring s_6, Fig. 26 (a), moves the end of the back-off lever w forwards, the casting w_5 slips off the screw r_{11} and allows the spring r_{12} to operate the lever r_{10} and put the part e_{14} of the drawing-out clutch in contact with e_{13} and the drawing-out motion in operation. At the same time that this is accomplished the driving belt is shipped from the second to the third driving pulley and another draw commenced, provided of course that the wedge q_4, Fig. 25, was in such a position when the carriage came in as to lock the detent lever q so that the arm o_4 of the belt lever may rise until stopped by t_4 in the position shown in Fig. 27 (a). If the detent lever is not locked the belt will remain on the pulley e_3, but as the drawing-in clutch and back-off friction are out of connection, no motion will be imparted to any part of the mule except the loose train of gears e_7, g_6, g_5, g_4, Fig. 6.

As the carriage reaches the end of its inward motion several other important reengagements take place. The roving motion is thrown into gear again by the roll c_6, Fig. 9, on the carriage striking the lever i. The dwell motion is also operated by the segment gear j_1, Fig. 13, coming in contact with the rack j. The fallers are also

caused to resume their position clear of the yarn preliminary to the next outward run of the carriage, in the following manner: As the carriage reaches the end of its inward run the faller leg b_7, Fig. 22, strikes a casting p_{31} bolted to the floor and is thus unlocked from the stud p_4. This allows the spring b_{18}, Fig. 31 (b), attached to the winding-faller shaft b_8 to raise the winding faller until clear of the yarn; that is, until its motion is checked by the stop b_{13}. The counter faller is lowered at the same time by means of a roll b_{22} attached to a casting that is bolted to the floor. This roll engages the inclined part of the lever b_{21}, raising it and also the rod b_{20} and lever b_{14} and thereby lowering the counter faller. As the counter faller is lowered the locking piece b_{16} attached to the counter-faller shaft engages with the roll b_{18} and locks the faller in position. When the faller leg b_7, Fig. 22, is struck by the casting p_{31} and unlocked, the rocker-shaft y_8 is operated and the half l_9, Fig. 30, of the winding clutch disengaged from l_{10}, and as the carriage starts to be drawn out again the center shaft c_{10} will be driven by the rim band.

This completes the cycle of movements of the mule during one draw of the carriage. The mule is now ready to repeat its operations for the next draw.

SPECIAL POINTS

DOFFING

57. When a set of bobbins becomes filled with yarn they must be removed and empty bobbins substituted; this operation is known as **doffing.** When doffing a full set of bobbins from the mule, the builder rail is first wound up while the carriage is coming out. This is accomplished by lifting the pawl p_{10}, Fig. 24 (a) and (b), and winding back the builder gear p_{21}, screw p_6, and consequently drawing the shoes p_5, p_6, p_7, Fig. 22, forwards by means of the crank-handle n, Fig. 18, which is removed from the quadrant screw for this purpose and placed on the screw shaft of the large builder gear, the end of which is square in section to allow

this. As the shoes are moved forwards the rail is raised, which causes the winding faller to go to the base of the bobbin when the fallers are changed by the backing-off motion. The mule is allowed to continue in operation until the fallers change, when it is stopped immediately by means of the shipper lever o, Fig. 25. The shipper lever is then given several sharp jerks, so that sufficient motion will be imparted to the mule to allow the spindles to make four or five revolutions. As the winding faller is down, this winds, or ties, the yarn around the base of the bobbins, thus preventing their unraveling during subsequent handling. The winding faller is next locked down by pressing it below the bobbin and fastening it by means of a small catch on the carriage provided for this purpose. Then by leaning over the carriage and pulling the rim band toward the carriage, motion is imparted to the spindles; this will wind the yarn around them and thus tie it so that the ends will not be broken down when the full bobbins are removed. It is well to tie the yarn firmly around the spindles, and as the turning of the spindles by means of the rim band gives slack quadrant chain, because the spindle drum is turned without drawing in the carriage, the carriage may now be *jerked* in by power until the quadrant chain is tight. This gives slack yarn because this movement of the carriage is accomplished without turning the spindles, the quadrant chain being slack. The counter faller is now locked down with the winding faller by means of the catch mentioned and the full bobbins removed from the spindles and placed in a basket. Empty bobbins may now be placed on the spindles and, by means of a short length of board, pressed down until their tops are flush with the tops of the spindles. Care should be taken in pressing down the bobbins in this manner to avoid bending the spindles or splitting the bobbins.

After all the bobbins are placed on the spindles, the quadrant pulley l_2, Fig. 18, is wound down to the bottom of its screw l_1 by means of the crank-handle n and the link in the quadrant-governor chain n_{14} turned down. The fallers may now be unlocked. Then by leaning over the carriage and

drawing the rim band toward the carriage a half turn of yarn may be wound around the new set of bobbins. After making sure that the quadrant chain is tight, the carriage is run in slowly, checking the power with the shipper lever; otherwise, the carriage will bang in hard against the back stops. If the quadrant chain is not tight, the faller leg b_7, Fig. 22, may be pulled out of contact with the stud p_4 by hand. This pulls over the rocker-shaft y_9, releases the winding clutch from contact, and allows the weight l_{14}, Fig. 5, to drop, turning the drum l_4, Fig. 18, by means of the rope l_7 and taking the slack out of the quadrant chain l_3. After the quadrant chain is tightened, the faller leg may be locked again by depressing the winding faller with the handle b_{10}, Fig. 22. Immediately that the carriage is drawn in against the back stops, the shipper lever may be pulled forwards and the mule started in operation.

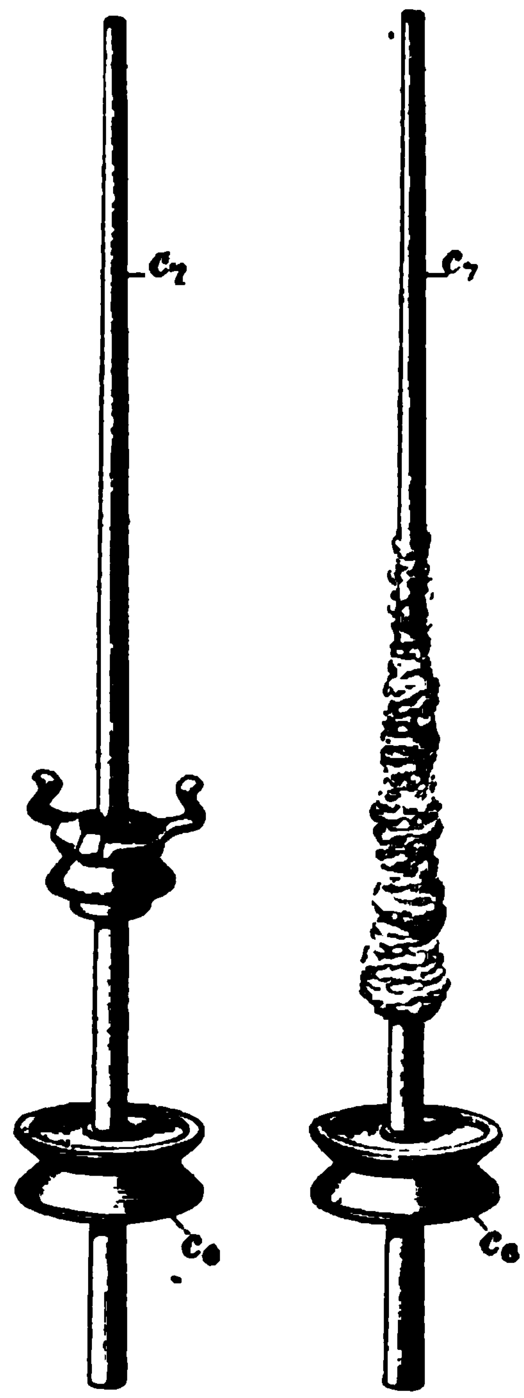


FIG. 33

BOBBIN CLIPS

58. In order to spin the yarn well, the bobbin must be level, or flush, with the top of the spindle; the usual method of accomplishing this is to wind packing yarn around the spindle so as to make the bobbin fit tight and be held at the right height. A better way to accomplish this result, however, is to use a **bobbin clip**, or holder, of which there are several kinds on the market. Fig. 33 shows a spindle packed with yarn in the old way and also one equipped with an ordinary type of bobbin holder.

Among the advantages of the bobbin clip may be mentioned the following: (1) It saves the packing under the bobbins and the time in putting it on. (2) It causes the

bobbin to run true by being held firmly and at a common center; that is, not allowing the bobbin to wabble in consequence of uneven yarn packing. (3) The bobbins are always flush with the top of the spindles and are not split or broken by being thrust over the packing. It also saves the use of a stick for pounding the bobbins down to their proper level. (4) It saves time in cutting off the excess of waste and packing from around the spindles.

59. An improved device for holding the bobbin on the spindle is shown in Fig. 34. This consists of a clip that is placed on the spindle and holds the base of the bobbin by means of three steel lips that are pressed on the bobbin by a spring.

Fig. 34

SPINDLE BANDS

60. In regard to the **spindle bands**, great care should be taken to replace loose bands, as they make soft bobbins, which greatly increase the amount of waste. The best band to use is an endless fulled-wool band. These may be purchased or may be made at the mill if the mill owns a spindle-band machine. Knotted bands are undesirable.

WASTE

61. The amount of **waste** made in a spinning room is governed to a large extent by the degree of care with which the draft is set to accommodate different batches and kinds of stock. If the draft is not adjusted properly, the ends will be constantly breaking, thus increasing the waste and also the labor of the spinner in piecing up ends.

Generally speaking, the longer and coarser the stock, the quicker the carriage should be drawn out. If the ends break close to the delivery rolls, it is an indication that the drafting is too slow. This is especially apt to be so in the case of long stock, as the long fibers take the twist more rapidly

and thus become hard to draw out to the required size of yarn. On finer stock, if the roving breaks about half way between the delivery rolls and the spindles when drawing, it is an indication that the carriage is being drawn out too fast. Short stock, or stock in which there is a liberal supply of waste, must be drawn much more slowly than the longer grades of wool.

Large alterations in the draft may be made by means of the draft gear e_9 or the intermediate draft gear e_{11}, Fig. 7. A larger gear in either case increases the speed of the draft scroll and consequently of the carriage, and a smaller gear has the opposite effect. The finer adjustments of the draft are made by changing the position of the drawing-out, or draft, scroll by means of the handle f_{10}, Fig. 13, or by changing the wings of the draft scroll.

With the draft set to conform to the grade of the roving, a mule should make very little waste. Waste in the spinning room is expensive, and as most of it is partly twisted and the rest has been mixed with hard ends on the floor, it is swept up and put with the hard waste at night. The spinners should be required to keep the waste off the floor and to keep the hard and soft waste separate.

It is a good plan to have two boxes or baskets attached to each mule, one for hard and one for soft waste. In this manner the spinner can keep the hard and soft waste separate and the latter can be mixed with good wool and run through the cards again.

CLOCK

62. A **clock** for registering the amount of yarn spun is generally applied to all modern mules, although it is of great value in cases where the spinners are paid according to the amount of yarn that they spin; but is often disconnected when spinners are paid by the day or week. As shown in Fig. 35, the clock motion is driven from the drawing-in shaft g, on which is fastened a worm z (see also Fig. 17) that imparts motion to a segment gear z_1 cast in the form of a bell-crank lever. To one arm of this lever is attached a rod z_2 that has

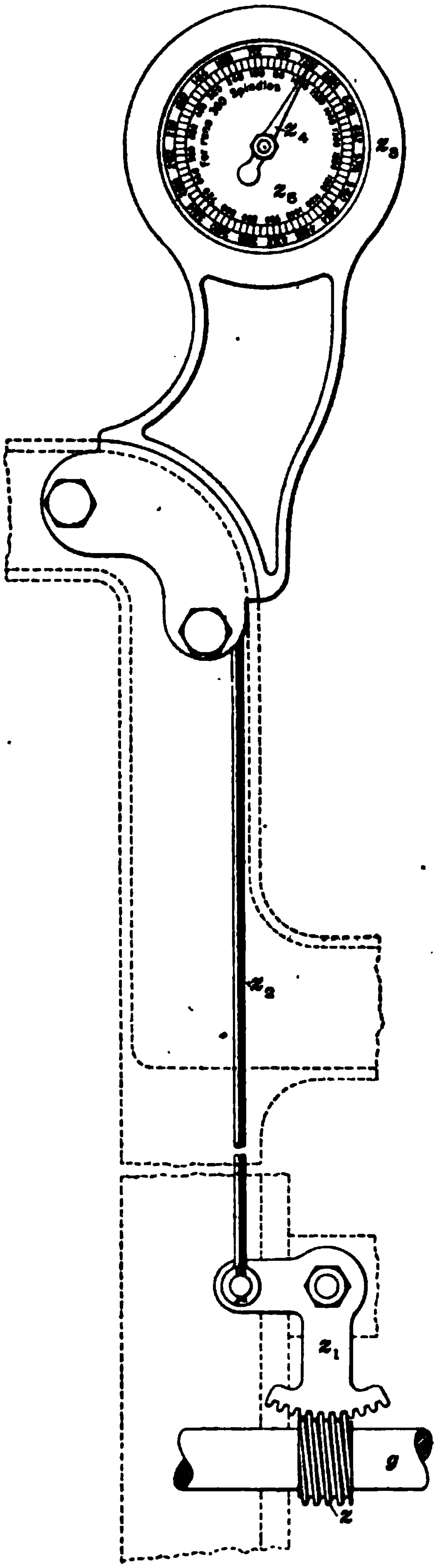


FIG. 85

on its upper end a pawl engaging with a 10-tooth ratchet gear contained in the clock case z_3. Compounded with this ratchet is a single-threaded worm meshing with a 160-tooth worm-gear, to the shaft of which the pointer z_4 is attached. As the carriage is drawn out, the rod z_2 is raised, but as it is drawn in, the motion of the shaft *g* is reversed and the rod lowered, the pawl on its end moving the ratchet 1 tooth. Ten draws of the carriage will therefore impart one revolution to the ratchet gear, as the latter contains 10 teeth, and since the 160-tooth worm-gear is driven by a single worm, 10 times 160, or 1,600, draws of the carriage will be required to move the indicator z_4 one complete revolution. The dial z_5 contains two rows of figures; the inside row is numbered from 0 to 1,600 and simply indicates the number of draws the carriage makes. The outside row of figures varies according to the number of spindles that the mule contains, and indicates the number of pounds of 1-run yarn spun. If the mule is a 360-spindle machine, the outside row of figures is numbered from 0 to 720, whereas if the mule contains only 280 spindles, the highest number of the outside row would

be 560; that is, the outside row of figures will register a number equal to twice the number of spindles, because the length of yarn spun at one draw by each spindle is 2 yards; or in other words, in 1,600 draws, or one revolution of z_4, a number of pounds of 1-run yarn equal to twice the number of spindles will be spun. If a mule is spinning yarn of any other size than 1-run, in order to find the number of pounds produced it is simply necessary to divide the reading of the clock by the size of the yarn. For instance, if a mule is spinning 3-run yarn and the clock registers 288 pounds, only $288 \div 3 = 96$ pounds of yarn has been spun; or if 4-run, 72 pounds, etc.

SIZE, GAUGE, SPEED, AND HORSEPOWER

63. The size of woolen mules is designated by the number of spindles, and mules are constructed with any number of spindles that may be required, the usual custom being for a mill to order mules of a size suited to its requirements. Such sizes as 120-, 160-, 200-, 220-, 260-, 300-, 320-, 360-, and 400-spindle mules are common sizes.

The gauge of a mule is the distance between the centers of two consecutive spindles. Ordinary woolen mules are generally constructed with a 1¾- or 2-inch gauge, although any gauge may be made, according to the requirements of any particular case. Heavy mules for spinning carpet yarns are usually made with a wider gauge than ordinary mules. Any increase in the gauge increases the length of the machine relative to the number of spindles.

The driving pulleys of the mule are 14 inches in diameter, and for ordinary woolen spinning should make from 320 to 360 revolutions per minute. Mules with a smaller number of spindles may be speeded faster than larger mules, which are generally speeded slower on account of the increased weight of the carriage in the latter case. Wide-gauged and heavy carpet mules should be speeded slower.

The horsepower consumed by a mule is a variable quantity, since while certain motions are in operation a very much larger amount of power is necessary than while certain other

motions are in operation. Thus, when the carriage starts away from the delivery rolls the power consumed is very great, whereas while the mule is backing off the power amounts to practically nothing. It may be stated that on an average a 300-spindle mule will require from 3 to 4 horsepower.

WOOLEN AND WORSTED WARP PREPARATION

(PART 1)

INTRODUCTION

1. Between the processes of spinning and weaving there are several intermediate operations necessary before the yarn that is to constitute the warp of a fabric can be placed in suitable form for the weaving process. The object of these operations is to place the warp yarn on the loom beam so that it may be readily unwound as the cloth is woven and in a manner best suited for making a perfect fabric in the loom. In order that this object may be accomplished, it is evident that a definite number of threads or warp ends must be wound on the loom beam, according to the specifications of the cloth to be woven, and that each of these threads must be of the same length; that is, the required length of the warp.

To obtain the best results in weaving it is also imperative that each end of the warp shall be laid on the loom beam under the same tension, so that the warp will leave the beam evenly and the threads have a uniform tension while being woven. This is important not only in order to avoid poor weaving or the production of faulty cloth from the loom; but also to produce a fabric so constructed that the subsequent operations will not injure it. For instance, suppose that a fabric is being woven in which all of the warp ends have the proper tension with the exception of a few threads that are wound

loosely on the beam. It must necessarily follow that these threads will be woven into the cloth loosely throughout the whole piece, and if the fabric is piece-dyed a light shade, they will dye *darker* than the body of the fabric. The reason for this is that in a thread that is loose in the fabric the fibers do not lie so closely together and so will absorb the dyestuff more readily, thus taking up more of the dye and becoming darker in shade. Even in cases where the goods are not dyed in the piece, there is a strong tendency for a loose thread to show more prominently on the face of the cloth, since it is not drawn down level with the other threads by the tension of the warp. In some fabrics, also, loose threads are liable to cockle, thus producing a serious defect and causing the cloth to be classed as seconds.

2. Not only is it necessary when making a warp to have the right number of ends on the beam for the cloth to be woven, but it is also necessary in the preparation of some warps to use differently colored threads and to arrange the pattern of the warp correctly in order that certain effects of coloring may be obtained in the fabric. By examining any piece of cloth that contains threads of different colors in the warp it will be seen that these colors are arranged in a definite order, or **pattern**, which is repeated a certain number of times in the width of the cloth. In order to weave such a cloth, it is evident that the colors in the warp must be arranged in the same order on the beam as they are arranged in the cloth.

3. Another operation that is sometimes performed during the preparation of the warp is the application of a suitable dressing compound, or **size**, to the yarn, the object being to glue down the projecting fibers and make the thread smooth, so that the chafing of the reed and harnesses will not wear or rough up the yarn during the operation of weaving.

4. When the warp has been wound on the beam in suitable form so as to be readily unwound while being woven, it is next necessary to draw the separate ends of the warp through the harnesses according to the designer's draft and

also to draw the correct number of ends through each dent of the reed. After drawing in and reeding, the preparation of the warp is complete and it is then placed in the loom by the loom fixer and the cloth woven by the weaver.

5. As a summary of the foregoing it may be stated that the yarn that is to compose the warp of a fabric must be wound on the loom beam with an even and uniform tension; the pattern of the warp and the number of ends in the warp must be regulated; the warp may or may not have a suitable sizing compound applied in order to enable it to withstand the weaving process to better advantage; and the yarn must be drawn in through the harnesses and reeded.

6. Processes Employed in Warp Preparation.—In order to accomplish these results there are four processes generally employed, the object of which is to ultimately make a warp from the yarn as it comes from the spinning room on bobbins. These processes are: (1) *spooling*, (2) *dressing*, (3) *beaming*, (4) *drawing in* and *reeding*. Although these operations are in reality separate and are so spoken of when considered separately, it is customary to speak of the operations of warp preparation in general as *dressing*, all of them being conducted in a department known as the *dressing department*, usually under the charge of the boss weaver, or sometimes in large mills, a boss dresser.

SPOOLING

THE SPOOLER

7. The first operation necessary in the preparation of a warp is that of **spooling,** the object being to take the yarn from the bobbins on which it is spun, or twisted, and wind it on dresser spools, or jack-spools. These spools are constructed with a long wooden barrel having a head on each end, and are made to hold a certain number of threads, depending on the capacity of the spooler. The machine for spooling the yarn is commonly known as a **spooler,** and is shown in Fig. 1.

8. Bobbin Stand.—A bobbin stand similar to that shown in connection with the spooler is always necessary when the yarn is received on bobbins, as is generally the case with woolen yarn. It is for the purpose of holding the bobbin securely, in order to allow the thread to be unwound.

Spoolers and bobbin stands are usually made for 40 ends, but occasionally for 48 ends; the number of ends is regulated by the number of holes in the guide bars of the spooler. Guide bars with a smaller number of holes can be substituted and used if necessary.

9. Operation.—The operation of the spooler is as follows, the references being to Fig. 2. The bobbins *a* are placed on fixed pins, or spindles, on the bobbin stand and the yarn is passed behind one of two rods a_1 that serve as guides, and thence over hooks in the top of the stand. From these hooks the yarn passes to another row of hooks in the top of the spooler. The yarn next passes through a perforated guide bar *b* that has a traverse motion and then around two tension rolls *c*, *d* that are covered with leather having a roughened surface.

From the tension rolls the yarn passes through another traversing guide e and is ultimately wound on the spool f, the bar e being for the purpose of building the yarn on the spool smoothly. The spool is driven by friction with the

FIG. 1.

drum h, on which it is held firmly by means of a device that will be explained later. The drum is exactly 1 yard in circumference, so that at each revolution that it makes, 1 yard of yarn is wound on the spool. The beam b_1, in which the

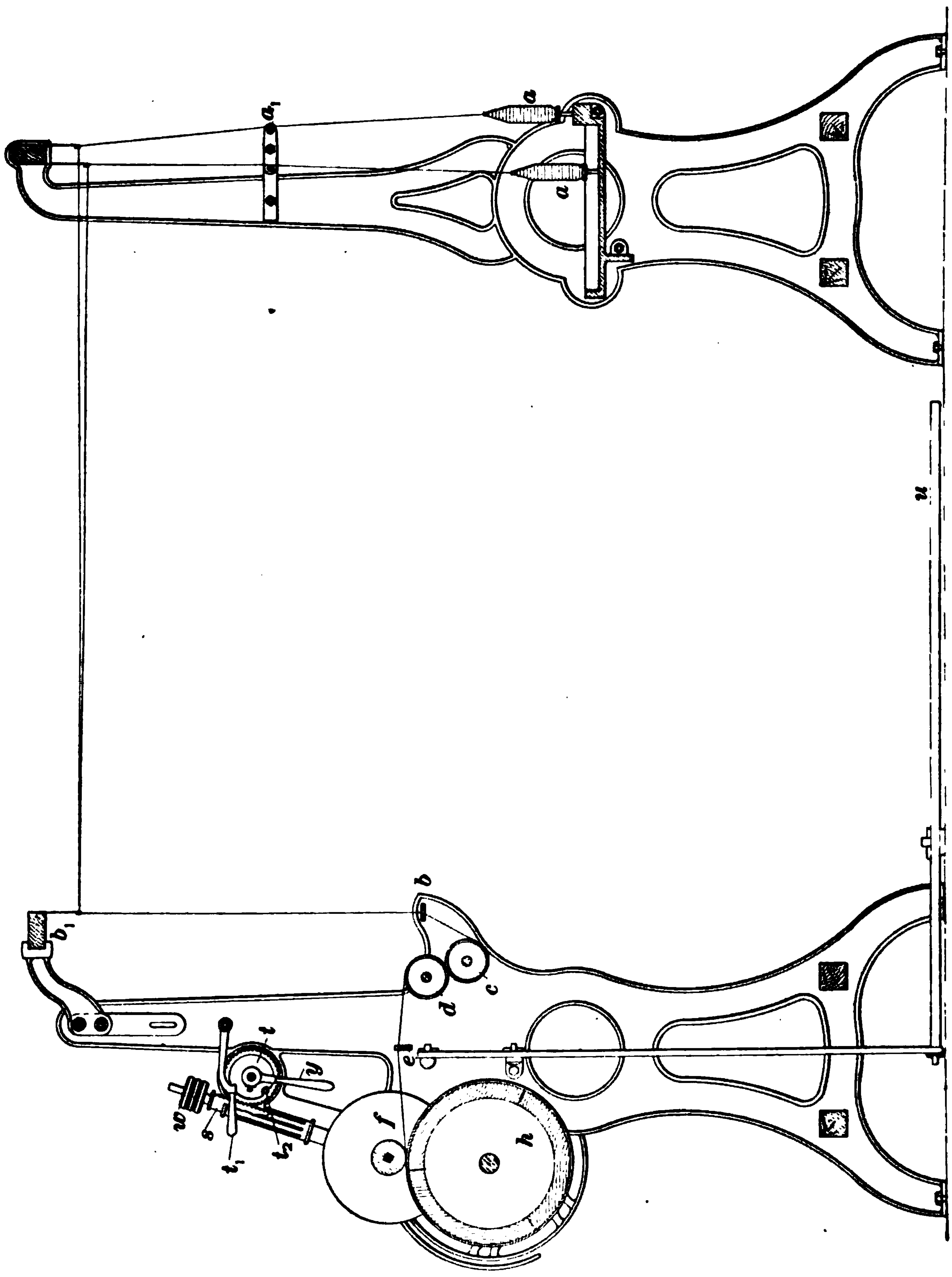


FIG. 2

row of wire hooks is placed, is adjustable by means of slots in its supporting uprights (as shown in Fig. 1), so that if the operative is of small stature it may be lowered in order to facilitate the work when tying in broken ends.

10. Tension Rolls.—The tension rolls *c*, *d* are driven only by means of the yarn passed around them; they thus regulate the tension with which the yarn is wound on the spool and also prevent kinks from passing forwards to the spool. The tension may be regulated by the position of the tension roll *d*, which may be moved farther back into another set of slots for increasing the tension or farther forwards to decrease the tension. The tension is also regulated in some cases by means of the frictional resistance of a cord fastened at one end to the framework of the machine; the other end is led around a grooved iron pulley at the end of the tension roll and has a weight attached. In this case more or less tension may be obtained by increasing or decreasing the amount of weight or the length of cord in contact with the pulley.

Although rolls covered with leather are best, many spoolers are equipped only with smooth, polished tension rolls. The guide *b* has a traversing motion, in order that the yarn shall not run in one place and thus wear grooves in the tension rolls, and also to correspond with the movement of the guide *e* and thus reduce the strain on the yarn as it traverses.

11. Measuring Motion.—There is a measuring, or clock, motion attached to the spooler, which is shown in Fig. 3, as well as in Fig. 1. On the shaft of the drum *h* is a worm h_1 that meshes with a 30-tooth worm-gear j_1 attached to a side shaft *j*. Attached to this shaft is a worm k_1 that meshes with a dial gear *k*. This gear is marked off so that the number of yards spooled can be readily ascertained. The drum *h* is 1 yard in circumference; the worm h_1 is a single-threaded worm; the worm-gear j_1 has 30 teeth; and the worm k_1 is single-threaded. Therefore, it will be readily seen that each tooth on the dial gear equals 30 yards

of yarn on the spool, and that in order to find the number of yards spooled it is simply necessary to multiply the number of teeth that the dial gear *k* moves by 30. This may also be reckoned by means of the scale marked on the dial gear.

There is an *alarm* connected with this mechanism whereby a bell is made to ring when a given number of yards has been spooled. In the dial gear *k* there is a row of holes, in any one of which a peg l_2, Fig. 4, may be placed. This peg

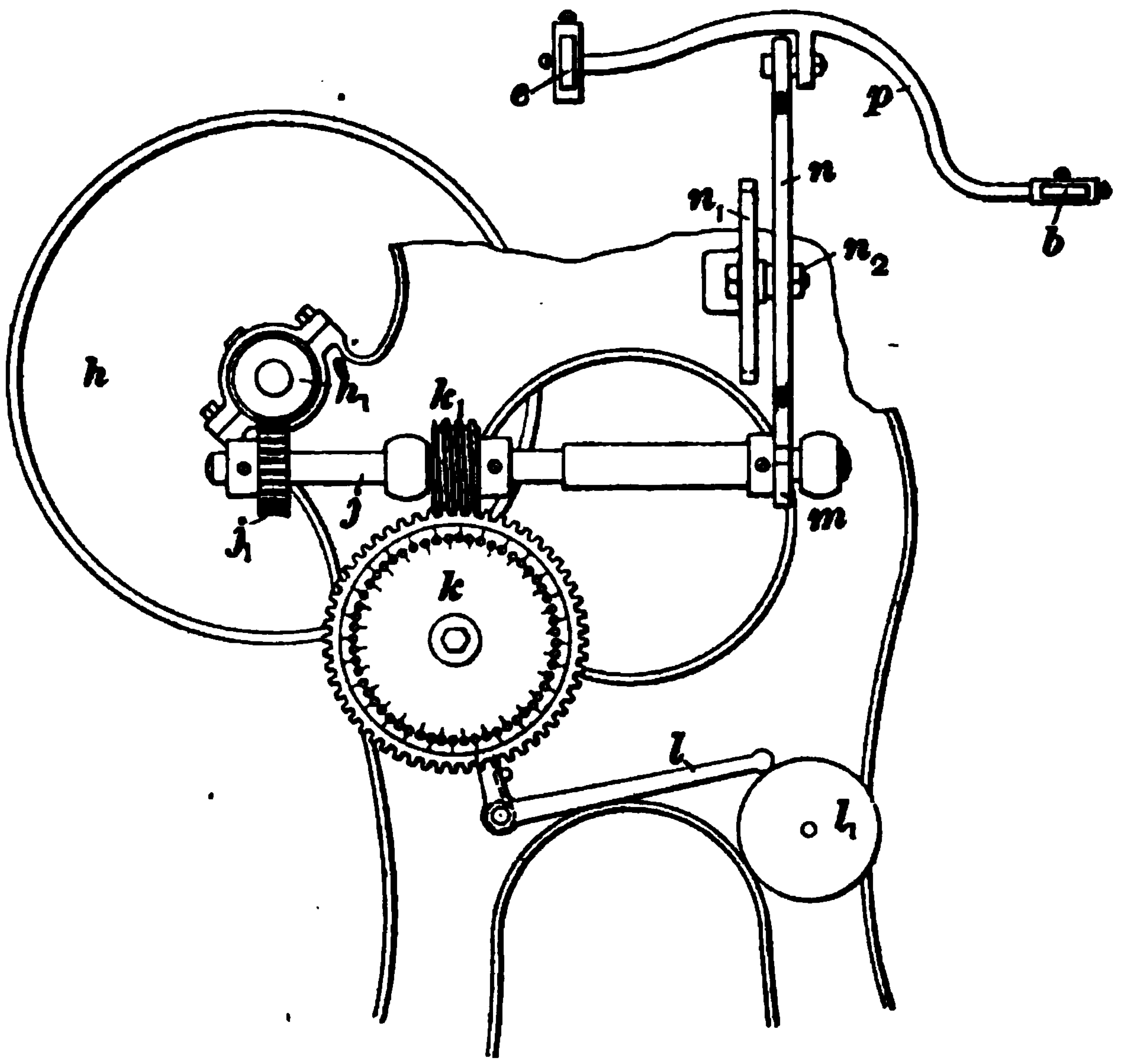


FIG. 8

when brought around by the rotation of the dial gear raises a hammer *l*, which is pressed against the bell l_1 by a coil spring upon the stud on which the hammer is centered. When the peg slips past the hammer, it will fall against the bell, thus notifying the operator that the desired number of yards have been spooled. It will be readily seen that the bell may be made to ring when any multiple of 30 yards of yarn has been spooled by simply placing the peg in the correct hole in the dial gear.

12. Traverse Motion.—One of the most important parts of a spooler is the traverse motion. Referring to Figs. 1 and 3, it will be seen that the guide bars *b*, *e* are connected outside of the frame of the machine by a curved bar *p*. By this means the guide bars are made to move in unison, thus not only keeping the tension rolls free from grooves and building a level spool but

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FIG. 4

without overlapping or being wound over the adjacent threads. Sometimes when making a pattern on the dresser a full spool is not wanted, in which case it may be desirable to alter the length of traverse. Suppose that it were necessary to have only 20 ends on a spool; then a thread could be drawn through every other hole in the guide bars and the traverse

increased to twice the original throw. This is not often done, however, and many operators would simply draw the 20 ends either in the middle or at one end of the spool, running perhaps an odd waste end of a different color at the side of the desired ends to keep them from slipping down. A spring e_1 tends to pull the guide bar e toward the side of the machine, and as the guide bar is connected to the lever n, the lower curved end of the lever n is constantly pressed against the face of the cam m.

As the cam revolves it will alternately allow the point of the lever n to move closer to or be forced farther from the shaft j, which will give a corresponding traversing movement to the guide bars b, e. As the cam m is a double one, it will cause two complete traverses of the guide bars to be made for each revolution of the shaft j.

13. Spool-Holding Device.—In order that a rotary motion may be imparted to the spool so that the yarn will be wound on the same, it is necessary that the spool shall be held in contact with the rotating drum with sufficient pressure to drive the spool by the frictional contact between it and the drum. It was formerly the custom to obtain this pressure by hanging weights with iron hooks upon the gudgeons, or journals, of the spool. The objection to this method is that it is apt to wear out the spools rapidly by loosening and otherwise damaging the journals, and is also inconvenient in the operation of the machine. A better method of holding the spool firmly in contact with the drum is that employed on the spooler shown in Fig. 1. In this case the journals of the spool are carried on bearings r formed in the ends of racks s. Weights w fastened to extensions of these racks exert a pressure on the journals of the spool and keep the latter in contact with the drum h with sufficient pressure to prevent slipping.

In order that the spool may be raised from the drum when replacing a full spool with an empty one, two gears t are fastened to a shaft passing across the machine. These gears mesh with the rack, and when the handle y is raised,

the racks and the spool also will be raised from contact with the drum. A pin t_2 on the gear t engages with the dog t_1, so that when the spool has been raised it is prevented from dropping again until the dog t_1 is disengaged from the pin.

Occasionally it will be found that there is some tendency for the spool to slip on the drum of the spooler, especially if the drum has become very smooth through wear. The clock of the measuring motion is therefore liable to register a greater length of yarn than is actually wound on the spool. A good way to prevent the spool from slipping is to wind a strip of rough leather around the drum until its surface is completely covered. Fillet card clothing with the teeth removed is a good material to use for this purpose. Covering the drum with leather not only prevents slipping, but also increases the diameter of the drum slightly, so that there is no danger of the amount of yarn on the spool being less than registered by the clock.

14. Belt Shipper.—Beneath the spooler, as shown at Fig. 1, there is a lever u pivoted on a pin projecting from the floor and connected with the belt guide, by means of which the belt may be shifted upon the tight-and-loose pulleys by the foot of the operator, thus allowing the machine to be stopped very readily for the purpose of tying in broken threads.

15. Speed.—The main driven pulleys of a spooler are usually from 12 to 14 inches in diameter, and for good results should run from 100 to 120 revolutions per minute.

16. Stop-Motion.—Nearly all modern spoolers are equipped with a stop-motion, which is a device for stopping the machine immediately when one of the bobbins becomes exhausted or a slug or tangle in the yarn causes an end to break. This motion therefore prevents imperfect spools from being made, since it will be seen that if the machine is not immediately stopped when an end breaks or runs out, many yards of thread will be missing on the spool because of the high velocity at which the drum of the spooler is driven. When this happens, the operator finds the broken

end and repairs it, of course without unwinding the yarn that has been spooled on other parts of the spool in the interval of time between the breaking of the thread and the stopping of the machine, with the result that the spool has one end that is several yards shorter than the others. If the broken end is much shorter than those on either side, it leads to another defect; for in this case a hollow of considerable depth is formed in the spool and the ends on each side have a tendency to fall into this and wind over the short end after it has been pieced up. When such a spool is placed in the creel behind the dresser, there will be difficulty in making it unwind properly without some of the ends becoming broken and imperfect work resulting.

Fig. 5 (*a*) and (*b*) shows a stop-motion applied to the ordinary type of woolen and worsted spooler. On the main shaft of the machine, which carries the drum *h*, an eccentric *l* is placed just inside the frame and on the pulley side of the machine. This eccentric imparts motion to an arm l_1, to which a casting l_2, having an inverted **V**-shaped slot in one end, is bolted. An oscillating rod j_1 extending across the entire width of the machine is supported from a shaft j_2 by arms, one of which *j* extends below the shaft j_2 and has a pin j_3 fastened at its lower end. The pin j_3 passes through the slot in the casting l_2, and as the rod l_1, l_2 has no support except from the eccentric *l* and the pin j_3, the upper part of the slot in l_2 rests loosely on the pin j_3 during the ordinary working of the machine. As the eccentric revolves, motion will be given to the pin j_3 and the lever *j* will be moved forwards and backwards about its fulcrum at j_2, and the rod j_1 will consequently have an oscillating motion. Each end *a* that is being spooled is threaded through a guide k_2 in a drop finger *k*, which is supported loosely by a rod k_1 extending from one side of the spooler to the other. Each drop finger is independent of the others, and can swing on the rod k_1. Besides having a guide for the thread to pass through, each finger is made with a projection k_3 extending downwards, and constantly tending to pull the finger down by its weight. The tension of the thread is sufficient to hold

(b)

FIG. 4

(a)

the drop finger in a raised position during the ordinary working of the machine, in which position it is impossible for it to come in contact with the oscillating rod j_1 situated just beneath it; but, if for any reason the thread should become broken or missing, the drop finger will fall, since it is so weighted as to be supported only by the thread. Whenever this happens, the extension k_2 on the drop finger will come in contact with the oscillating rod j_1 and check its motion; the lever j will therefore also be held firmly, and, since the eccentric l is not stopped and the pin j_2 is held fast, the casting l_2 rises because of the upper edge of the slot being forced past the pin j_2. As the slot provides an inclined surface on either side of the pin j_2, it is immaterial on which side of the extension k_2 on the drop finger the rod is engaged. When the casting l_2 rises it will tighten a chain l_3, which in turn will raise a lock lever l_4 and thus release a lever m fulcrumed at m_1. At the end of the lever m is a stud m_2 to which a spring m_3 fastened at the opposite side to the framework of the machine is attached. When the lock lever l_4 is raised and the lever m released, the spring draws the lever over, and the stud m_2 coming in contact with a finger n_2 set-screwed to the shipper rod n_1 forces the belt from the tight pulley n to the loose pulley n_1 by means of the guide n_3 through which the belt passes. The finger n_2 does not interfere with the regular shipping of the belt, and when the broken end has been replaced the shipper rod is forced back again, in so doing shipping the belt to the tight pulley and forcing the lever m back so that it will again be locked by the lock lever l_4.

If it is desired to make a spool with fewer ends than there are drop fingers, the unused drop fingers must be raised so that they will not stop the machine. This may be accomplished by passing a wire through the holes in the rear of the fingers, the weight of the wire holding the fingers in a raised position; or the fingers may be tied up.

WORSTED CREEL

17. When worsted yarn is being spooled, it is usually necessary to substitute a creel for the bobbin stand shown in Fig. 1, since worsted yarn is usually received in the dressing room on small spools. Fig. 6 shows a common type

of creel used for this purpose. It consists simply of a wooden framework arranged so that the spools containing the yarn may be placed on wooden skewers, which are supported in slots cut in the framework of the creel. In order to secure enough friction on the spool to prevent the spool from overrunning when the spooler is stopped, small castings are hung loosely upon rods extending across the creel. These

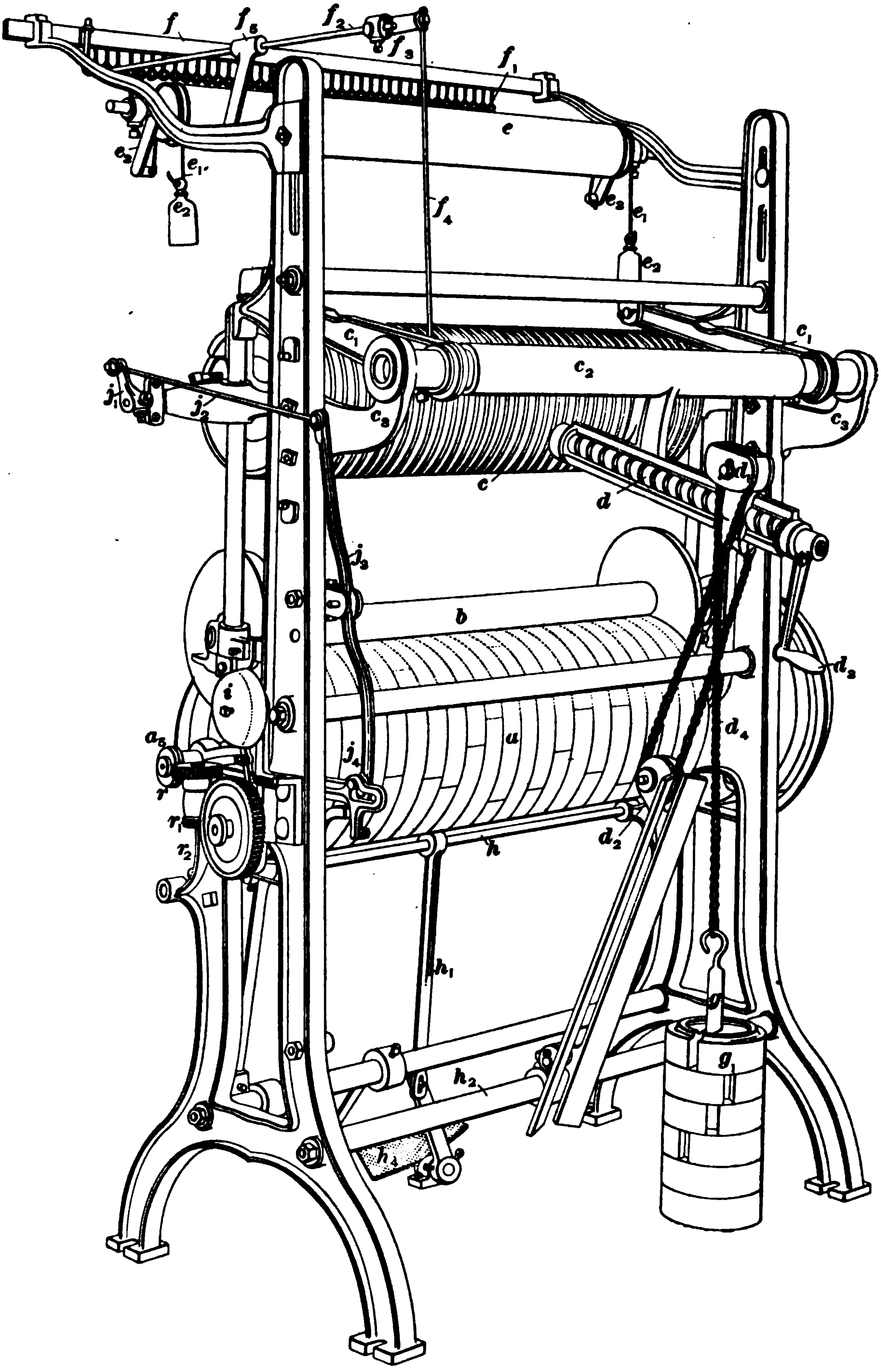
castings are grooved on the under side so that they will fit over the head of the spool and by virtue of their weight prevent the same from turning too freely. Sometimes instead of iron castings, small wooden paddles are used for placing the friction on the spools. These are usually arranged to rest on the surface of the yarn and not on the head of the spool.

THE COMPRESSING SPOOLER

18. In the ordinary type of spooler the hardness of the spool is regulated to a great extent by the amount of tension that is placed on the yarn during the spooling. If any attempt is made to increase the firmness by increasing the weight on the journals, or gudgeons, of the spool, it will result in greater pressure being exerted on the ends than in the center of the spool, as the spool tends to spring at the center. This will make a spool with a greater diameter in the center than at the ends and will result in unsatisfactory warps, since the fact that some ends are wound loose and others tight causes uneven tension. If an increase of the firmness of the spool is obtained by placing a greater tension on the yarn, the results are even more unsatisfactory, since in this case not only will the elasticity of the yarn be injured, but frequent stoppages with consequent loss of production will be necessary on account of the tension frequently breaking the yarn.

It is the object of the **compressing spooler** to overcome these difficulties and to wind the yarn on the spool in such a manner that not only will each thread have the same length, but the spool also will be made much firmer and will contain from 30 to 50 per cent. more yarn than a spool made in the ordinary way. This latter point is of great advantage in itself, since the spools will run longer in the dresser, and consequently the time consumed in tying in new spools and the number of knots in the warp will be reduced to a minimum. Since increased firmness of the spool is obtained by this system without undue tension on the yarn in spooling, the elasticity of the yarn is not impaired in the least, but is

FIG. 7



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d2
h
h1
g1
h2
h4

Fig. 8

fully retained. A front view of the compressing spooler is shown in Fig. 7 (*a*), while Fig. 8 shows the appearance of the machine as seen from the rear. It is important to notice that Fig. 7 (*a*) shows the machine in operation, while Fig. 8 shows it stopped for the removal of a full spool.

19. The operation of this spooler is as follows: The spool b, on which the yarn is wound, is carried on the usual rotating drum a, which is covered with a filleting of rough leather. Resting on top of the yarn as it is wound on the spool is a heavy iron compressing roll c supported in bearings at the end of two arms c_1, c_1. These arms are attached to a shaft c_2 that is journaled in brackets c_3, c_3, which are bolted to the side frame of the machine.

The object of this roller c is to exert a heavy pressure on the spool, so that the yarn will be wound in such a manner as to form a firmly compressed spool. The pressure on the yarn is obtained by the weight of the compressing roll itself, and also by means of the weights g_1 at the rear of the machine. Carried in a casting that is part of the shaft c_2 is a screw d, which may be turned by a crank d_3; this screw carries a sliding block d_1, in which a pulley is mounted. Attached to the bottom of the block is a chain d_4, which is led through a pulley d_2 attached solidly to the framework of the machine, then back through the pulley in the sliding block and finally to a spindle g, upon which a number of weights g_1 may be placed, according to the desired pressure to be exerted by the compressing roll. The object of the screw arrangement is to provide for the raising of the compressing roll when it becomes necessary to remove a full spool from the machine and replace it with an empty one.

While the machine is in operation, the compressing roll rests on the surface of the yarn, and the block d_1, being screwed to the end of the screw nearest the compressing roll, passes the fulcrum of the shaft c_2 and exerts a downward pressure on the compressing roll, thus holding it firmly on the yarn. When, however, it is desired to raise the compressing roll for replacing the full spool with an

empty one, the block d_1 is screwed back to some such position as is shown in Fig. 8. When this is done, the weight g_1 will operate outside of the fulcrum, and the weight of the compressing roll will be counterbalanced so that it may be raised.

20. Traverse Motion.—The compressing roll is cut with a number of grooves corresponding to the number of ends that it is possible to place on a full spool. These grooves take the place of the traversing thread guide in the ordinary type of spooler. They are somewhat V shaped and about $\frac{3}{16}$ inch in depth, and instead of being cut in a true circle around the compressing roll, are cut at an angle, so that as the compressing roll rotates, the grooves have an oscillating motion and the thread is guided back and forth the distance between two rings. By this means, the traverse motion is obtained without any chafing of the yarn as is the case with the traversing guide bar on the ordinary type of spooler.

Fig. 7 (*b*) shows the arrangement of the grooves on the compressing roll and illustrates the principle on which the traverse action of the roll is based. With the roll in the position shown, the thread is being wound on the jack-spool at a point x_3, exactly in the center of its traverse motion, but as the roll continues to revolve, the point x will come in contact with the spool and thus guide the thread to the left. The continued movement of the compressing roll will then bring the thread back as the point x_1 is exactly over the point x_3. Then, as the motion continues, the thread will be carried to the right as the point x_2 is brought in contact with the spool, and so on, until the point x_2 is again reached.

It will be seen that in making a half revolution between the points x and x_2 and through the points x_1 or x_3, the thread will be traversed the distance y, which is equal to the distance between two rings. It will also be noted that the thread is traversed to the right and then back again to the left in one revolution of the compressing roll, that is, it

makes one traverse to each half revolution of the roll; and since the circumference of the compressing roll is 25 inches, one complete traverse is obtained with 12½ inches of yarn, whereas in the ordinary spooler, 15 yards of yarn is necessary for each traverse. This renders the spool especially firm, and if only a few ends are to be spooled it is unnecessary to run extra ends on each side, since the traverse is so short that the yarn will build up squarely without any support at the sides. Another advantage of this traverse motion is that if, when tying in a broken end, the operator should place the end in the wrong groove of the compressing roll, in one revolution of the roll the thread would be carried back to its proper groove, in which it would drop and continue to run. The reason for this is that the tendency of the thread to stay in the groove is not sufficient to cause it to stay in a groove on either side of the proper one for the reason that the thread is pulled out of its true course and compelled to run in a direction that forms an angle with the direction in which it is inclined to run.

21. Tension Roll.—The yarn that is being spooled is taken from a bobbin stand of ordinary construction and passed overhead through wire hooks f_1, then round a tension roll e, then through a small porcelain pot eye k to the spool. The object of the tension roll e is not so much that of placing tension on the yarn as to regulate the yarn so that the same length of each thread will be delivered. The tension is obtained by means of cords e_1 fastened to a casting e_3 and passing over a groove in each end of the tension roll. On the other end a weight e_2 is hung, thus securing the requisite friction. This friction may be easily varied by means of the casting e_3, which is setscrewed to the stationary shaft of the tension roll e and may be readily turned in either direction, by loosening the setscrew so that more or less of the cord will be in contact with the tension roll. If more of the cord is in contact with the roll, the friction will be increased, and vice versa. With this type of spooler, very little friction should be placed on the tension roll, since the object of

this machine is compression rather than tension. The tension roll is covered with leather in order that it may firmly grip the yarn, and the bar f in which the wire hooks are placed is given a slow lateral movement so that the yarn will not wear grooves in the roll. This movement is obtained by means of the rod f_4 attached at one end to the arm c_1 of the compressor and at the other to a casting f_3 setscrewed to the rod f_2, which is carried in a bearing f_5 bolted to the frame of the machine; the other end of the rod f_2 is bent at right angles to the main part of the rod and engages with the bar f. As the spool builds, the compressor roll and the arms c are raised, this motion imparting a slight lateral movement to the bar f so that it will gradually move to the left in Fig. 8. This traversing motion, of course, is very slow, since only one traverse is made while the spool is building.

22. Slow Motion.—A slow motion is attached to the compressing spooler so that the machine may be run at a slow speed while bobbins are being tied in or while the operator is watching for a bobbin to run out. At other times the machine may be run at its maximum speed. The position of this motion is shown in Fig. 7 (a), but Fig. 9 shows its construction in detail. The main shaft of the machine, on which the drum a is fastened, carries three pulleys a_1, a_2, a_3; the pulley a_3 is a tight pulley and is setscrewed to the shaft of the machine; the narrow pulley a_2 is the slow-motion pulley and is loose on the sleeve p; the pulley a_1 is a loose pulley and is loose on the same sleeve as the slow-motion pulley. On the inside of the loose pulley and fastened to the sleeve p is a gear q meshing with a gear q_1 loose on a stud fastened to the framework of the machine. Compounded with this gear is a gear q_2, which drives a gear q_3 fastened to the main shaft of the machine. On the other end of the sleeve p is a ratchet p_1, which is driven by means of a pawl p_2 fastened to the slow-motion pulley. When the belt is on the loose pulley a_1, no motion will be imparted to the machine; but when the belt is on the slow-motion pulley a_2, the pawl p_2

will engage the teeth of the ratchet p_1 and drive the drum a at half speed through the sleeve p and the gears q, q_1, q_2, q_3. When the belt is on the tight pulley a_1, the machine will be driven at its full speed.

The reason for driving the slow motion with a pawl and ratchet, as shown, is that as the belt takes hold of the tight pulley in being shifted from the slow-motion pulley, the slow-motion pulley, if fast to the sleeve, would begin to run at a speed in excess of that of the tight pulley, because

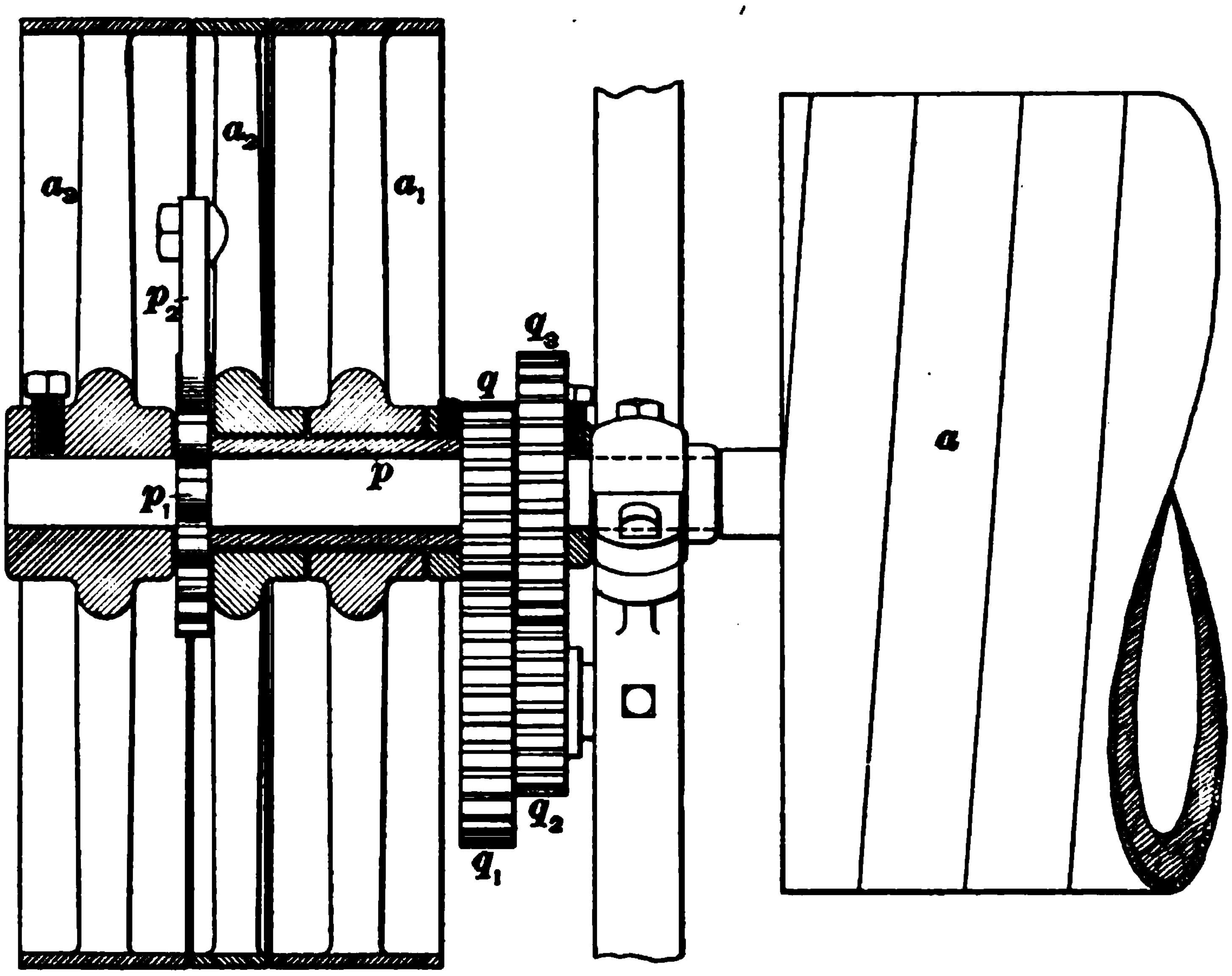


Fig. 9

motion would be imparted to the slow-motion pulley from the pulley a_1 by the gears q_3, q_2, q_1, q. This letting go of one pulley and taking hold of another would make a jump in the speed, since the slow-motion pulley would act as a brake until the belt was shifted entirely on to the fast pulley, if it were not for the pawl and ratchet. The pawl makes a release, so that as the belt begins to take hold of the tight pulley it releases the slow-motion pulley, which makes the latter act as a loose pulley.

The belt is shifted on the three pulleys by means of the shipper rod h, Fig. 7 (a), on one end of which an iron hoop h_5 is setscrewed. To this hoop an adjustable belt guide h_6 is fastened; this belt guide, together with the hoop, to which it may be fastened in any position, is so constructed that a belt may be guided on the pulleys when delivered at any angle. Attached to the shipper rod is a casting h_1 at the lower end of which is a slot engaging with the lever h_2, which is attached to a rod h_3 carried in bearings on the floor. A treadle h_4 attached to this rod enables the machine to be easily started or stopped.

23. Measuring Motion.—The compressing spooler is equipped with a measuring motion very similar to that previously described. On the main shaft of the machine is a single-threaded worm a_6, Fig. 10, engaging with a worm-gear r of 30 teeth. This worm-gear is fastened to a small upright shaft carried in a bearing bolted to the framework of the machine. Fastened to the lower end of the upright shaft is another single-threaded worm r_1 engaging with the dial, or clock, gear r_2, which contains 100 teeth. In this gear is a pin r_3, which is for the purpose of ringing a bell i whenever the desired number of yards has been spooled. This pin comes in contact with a hammer i_1, forcing it away from the bell i against the tension of the spring i_2. As the gear r_2 revolves, the hammer i_1 slips off the pin r_3 and the spring draws it forcibly back, thus ringing the bell. The drum a is exactly 1 yard in circumference; the worm a_6 is single-threaded; the worm-gear r has 30 teeth; and the worm r_1 is single-threaded. Therefore, 1 tooth of the dial gear equals 30 yards of yarn wound on the spool, and since the dial gear contains 100 teeth, one revolution of the latter will equal 3,000 yards of yarn spooled. When the pin r_3 is in such a position that the hammer i_1 has just slipped from it and rung the bell i, the 3,000-yard mark on the dial gear r_2 will be exactly opposite the pointer r_4, and since one complete revolution of the dial gear will be required before the bell will ring again, it follows that 3,000 yards of yarn, as indicated

by the pointer, will be spooled before the bell rings again. If any other number of yards is desired to be spooled, the dial gear is loosened, removed from the worm r_1, and

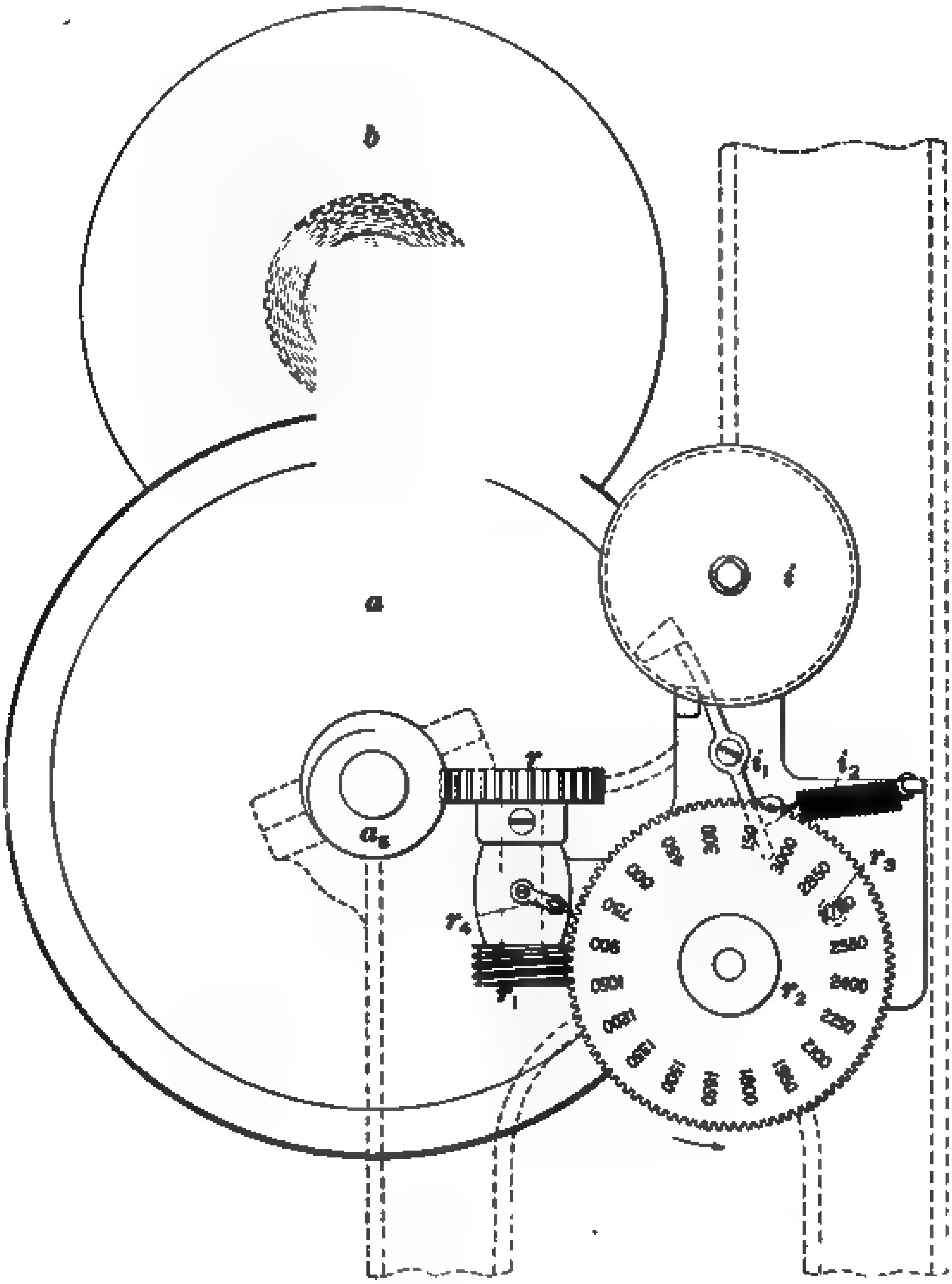
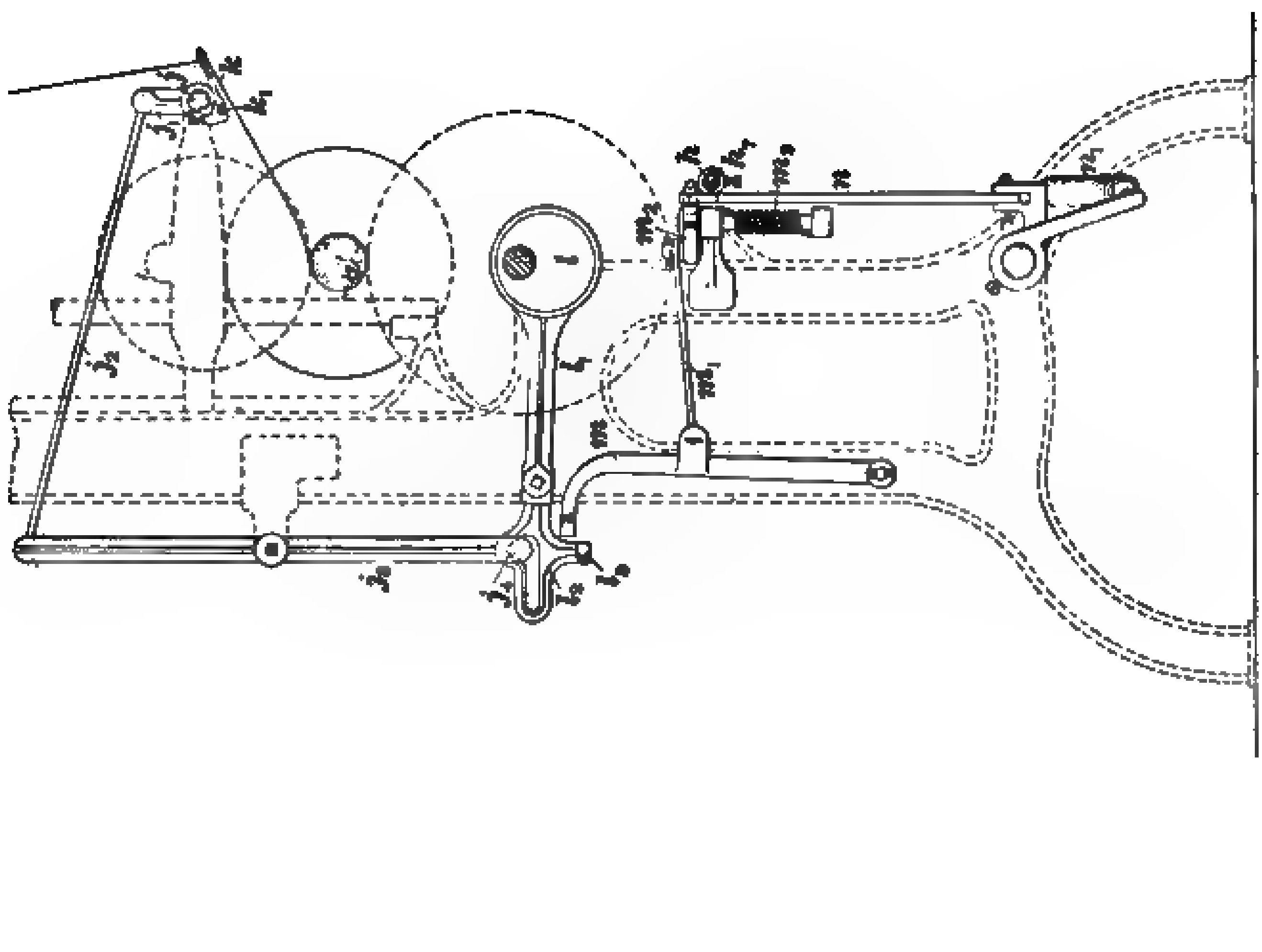


FIG. 10

replaced in such a position that the pointer r_4 will indicate the desired number of yards, which number will therefore be spooled before the bell will ring.

24. Stop-Motion.—The compressing spooler is equipped with a very simple and reliable stop-motion for stopping the machine when any thread becomes broken or runs out. This motion is shown in Fig. 11 (*a*) and (*b*), the former showing the device as seen from the side and the latter as seen from the front of the spooler. The yarn in passing to the spool is carried through small porcelain pot eyes in the end of drop fingers k, which are so arranged as to be supported by the tension of the thread. These drop fingers are fulcrumed at k_1 and have a small projection designed to engage with the grooved oscillating bar j, if for any reason the thread becomes broken and allows the finger to drop. Motion is imparted to the oscillating rod j by means of the eccentric l on the main shaft of the machine. This eccentric imparts motion to an arm l_1, at the end of which is bolted a casting l_2 having a long slot with a V-shaped notch at the top. A pin j_4 fastened in a lever j_3 supports the casting l_2 and the arm l_1 when the machine is in a normal condition, the pin resting in the V-shaped part of the slot. By this means the eccentric imparts an oscillating motion to the lever j_3, which through the connecting bar j_2 and the casting j_1 setscrewed to the end of the grooved bar j imparts an oscillating motion to the latter. Whenever a thread breaks and the drop finger engages the grooved bar, the oscillation of the latter is checked, which in turn stops the lever j_3. The movement of the eccentric then draws in the arm l_1 so that the pin j_4 will move out of the V-shaped slot, in so doing raising the casting l_2. At the end of the casting l_2 is a small projection l_3, which ordinarily clears the curved lever m; but, when the casting l_2 is raised, l_3 comes in contact with the end of this curved lever. When this happens, the action of the eccentric will impart motion to the lever m, and, through the connecting-rod m_1, to the lock lever m_2. The catch in the end of the lock lever ordinarily holds in position the lever n, which is forced against it by a strong spring n_1; but, when the rod m_1 is pushed back, the casting is turned on its shaft and releases the lever, which then

(b)



(a)

Fig. 11

comes in contact with the collar h_7 setscrewed to the shipper rod h, and by means of the spring n_1 forces over the shipper rod and shifts the belt from the tight to the loose pulley. A spring m_3 is so arranged as to hold the lock lever m_2 in contact with the lever n, so that the spooler will not be stopped by the vibration of the ordinary running of the machine. A recess in the lock lever receives the lever n when the machine is stopped by the stop-motion.

WOOLEN AND WORSTED WARP PREPARATION

(PART 2)

DRESSING

INTRODUCTION

1. Dressing is the process of unwinding the yarn from the spools and arranging it in the form of *sections*, in which each thread has its proper place and is arranged parallel to the other threads. These sections are then arranged side by side on a large reel until a sufficient number have been obtained to form the entire warp. Sometimes, during the dressing, a suitable sizing compound is added to the yarn so that its strength is increased and the breakage of the warp in the loom reduced to a minimum. The machine through which the warp yarn is passed for the purpose of applying this size and to arrange the spools of yarn into sections of the warp is known as a *dresser*.

As it would be impracticable to handle at one time in the dresser the total number of threads necessary to form even a narrow warp and at the same time to properly arrange the ends and apply the sizing compound, the necessity of forming the warp in sections is apparent. The number of ends that are to form one section of the warp are therefore spooled and the spools thus prepared placed in a creel at the rear of the dresser. The yarn from these spools is then passed through the dresser, where the size is applied and the

yarn dried, after which it passes to the large reel. When one section of the warp has been wound on the reel, the yarn is cut and another section of the same length wound on the reel beside the first section. This operation is repeated until the total number of ends and the total width of the desired warp is obtained.

DRESSERS

COMBINATION DRESSER

2. There are several types of **dressers,** varying principally in the method of drying the yarn after the application of the size. In the **combination dresser,** which takes its name from the method of drying the yarn, this is accomplished by the combined action of a heated copper cylinder and several banks of steam coils. Fig. 1 is a view of the general construction of the machine, while Fig. 2 is a section showing the passage of the yarn from the dresser spools in the creel to the warp reel.

3. Application of the Size.—The yarn passes from the dresser spools *a* through the reed *b*, which is known as the **tying-in reed,** and serves to separate each end of the section so that the spools can be properly tied in, and then between two light-running rolls *c*.

The sheet of warp threads next passes between the size roll *d* and the squeeze roll *p*, which is usually covered with cloth. Nearly half of the circumference of the size roll is immersed in the size contained in the size pan *e*, which is a narrow trough extending across the entire width of the dresser. The size is kept at the right temperature either by means of steam coils immersed in the size, or by making the size pan with a false bottom, thus forming a tight compartment underneath, into which live steam can be admitted. This latter arrangement is known as a *steam-jacketed size pan* and is, on the whole, preferable to the other method. The bottom, or size, roll brings up the size and applies it to the yarn as it passes between the two rolls.

The top roll acts simply as a squeeze, or press, roll to work the sizing compound into the yarn and at the same time to remove all the excess. The pressure on this roll is controlled by two levers *f*, one on each side of the machine; it may be regulated by means of the weights f_1, which if moved nearer the end of the lever will increase the pressure, and decrease it if set nearer the roll. Sufficient pressure should be applied to the yarn passing through the squeeze rolls to insure the removal of all the excessive size, which flows back into the pan over the surface of the roll *d*.

4. Drying.—After being sized, the yarn passes between coils of heated steam pipes to a skeleton roll *h* and then to another skeleton roll h_1, passing through the heated steam coils for the second time. Skeleton rolls are constructed with a number of projecting blades, on which the yarn rests. These extend the full width of the roll and prevent the yarn from touching any portion of the roll except the top of the blades. Their use is due to the fact that if the yarn while still moist and extremely adhesive by reason of the nature of the size applied to it were to come in contact with a smooth roll, there would be a tendency for it to stick and wind around the roll, thus causing a serious smash. This is very liable to happen if the machine is stopped for a time, since a stoppage allows the yarn to become securely attached to the rolls. As the yarn only touches at four or five points on a skeleton roll, there is no danger of this occurring, and, as it becomes somewhat drier in passing between the steam coils, the danger is entirely obviated and skeleton rolls are no longer necessary.

After passing around the skeleton roll h_1, the yarn passes back between the heated steam coils and then over a smooth tin roll *j* and around the steam-heated copper cylinder *k*. From the copper cylinder it passes through the steam coils again to a smooth tin roll *l*, and then back through the coils to another tin roll l_1. From this latter roll it finally passes over the steam coils and emerges from the dresser by passing around the measuring roll *m*; it then passes along the

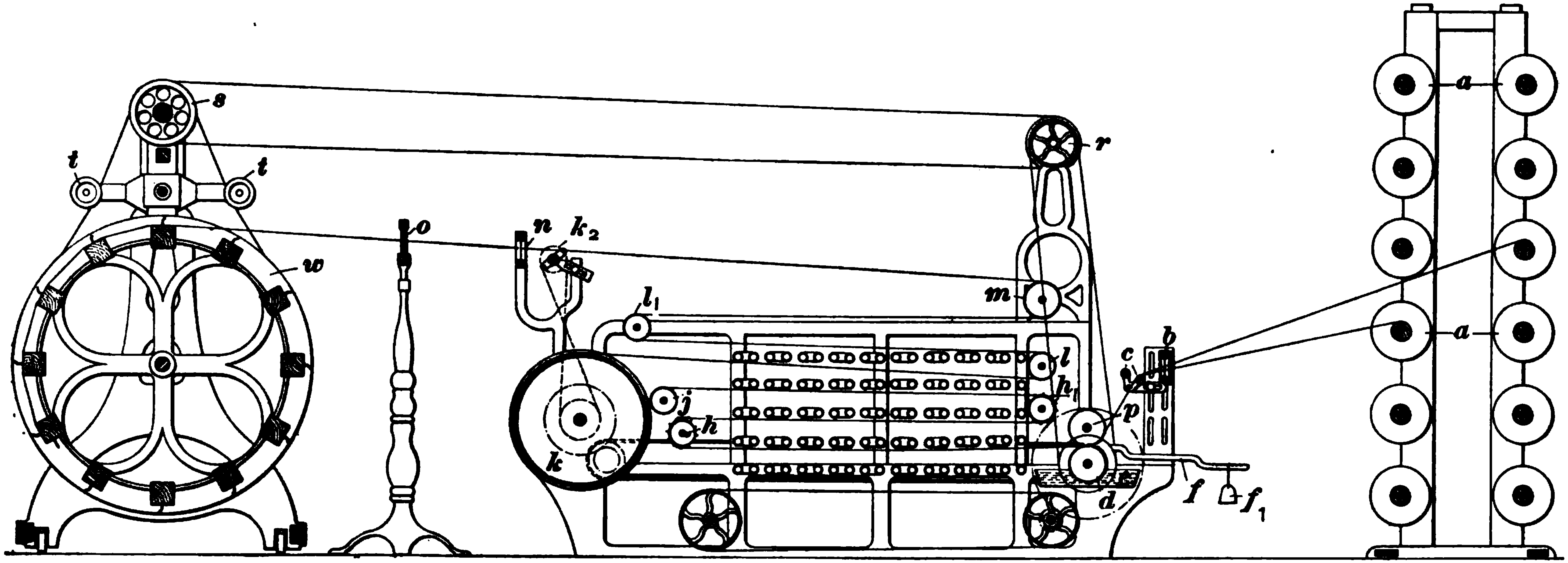


FIG. 2

top of the dresser, through the lease reed *n* and the condensing reed *o* to the warp reel, upon which the section of yarn is wound.

By this method the yarn is subjected to the heat of the steam coils six times after being sized, as well as being passed around the heated copper cylinder, so that the yarn is thoroughly dried before it is wound upon the reel. If it were placed on the reel while moist with size (which is largely composed of glue), the separate threads would become glued together and it would be practically impossible to weave or even beam the warp without an excessive number of broken ends, and even if it were woven, it would be a poorly running warp and would cause much trouble in the weave room. If a warp is not thoroughly dried, there is also great danger of mildew, which is a fungus growth caused by the damp condition of the yarn. When portions of a warp are mildewed, they cause spots in the woven cloth that it is impossible to remove.

5. The **combination dresser** is a very rapid dryer, as the heating capacity is large, consisting of five coils of steam pipe with eighteen pipes in a coil, as well as the large copper cylinder. It is sometimes built with eight coils of pipe and the length also may be increased indefinitely, allowing any number of pipes to be placed in a coil, so that the heating capacity is practically unlimited. Sometimes, when especially ordered, this dresser is built without the copper cylinder; in this case the yarn is dried simply by means of the steam pipes, and there is no doubt that this is to be preferred for dressing the very finest yarns.

The machine is arranged to be connected with a pipe from the boilers for the supply of steam, in which case a reducing valve should be used for reducing the pressure, or it may be connected directly to the steam-heating pipes. The pipes and copper cylinder of the dresser are tested with 40 pounds steam pressure before leaving the machine shop, but in practice a 15-pound steam pressure is sufficient for obtaining any results that may be desired, while dressers are ordinarily

run with from 8 to 12 pounds pressure. It is provided with a safety valve k_4, which should always be kept in working order and set so as to blow off at the required steam pressure; otherwise, there is the liability of an explosion of the copper cylinder or the steam pipes.

The copper cylinder is also provided with an atmospheric valve, which admits air to the cylinder when the steam is turned off. This is necessary because as the cylinder is cooled a vacuum is formed inside by the condensation of the steam, and the pressure of the air on the outside tends to collapse the cylinder unless means are adopted for equalizing the internal and external pressures. The top and sides of the dresser are enclosed with wooden and sheet-iron coverings, which greatly aid in retaining the heat and consequently in the rapid drying of the yarn. It also increases the production of the machine, since, if dried rapidly, the yarn may be run through the machine faster. The comfort and efficiency of the operator are also promoted by enclosing the machine, since the covering furnishes protection from the intense heat. The side panels may be removed and the yarn exposed in order to piece up broken ends or for any other purpose. One of these panels is shown removed in Fig. 1.

6. Shaking Motion.—A **shaker,** or beater, is usually applied to dressers for the purpose of shaking the yarn just before it passes through the lease reed *n*, in order to loosen and free all threads that may be adhering to one another because of the adhesive nature of the sizing compound, so that they will pass freely through the reed without being broken. This device k_5 consists of two parallel rods fastened on opposite sides of a rotating shaft, and driven by means of a cord from a grooved pulley on the cylinder shaft. The sheet of yarn passing through the reed rests on the rods, which, in rotating, shake apart the ends that may be stuck together with size. This mechanism also prevents the yarn from wearing the lease reed in one place, thus greatly lengthening the life of the reed.

7. Measuring Motion.—The **measuring, or clock, motion** on the combination dresser is very similar to the one on the woolen spooler. On the shaft of the measuring roll m is a single-threaded worm m_1 that meshes with a dial, or clock, gear m_2 containing 120 teeth. The measuring roll is 18 inches, or $\frac{1}{2}$ yard, in circumference, so that one revolution of the clock gear will equal 60 yards of yarn passed over the measuring roll. There is a bell and hammer operated by a pin placed in the clock gear, as on the spooler.

8. Driving.—Beneath the dresser is a pair of cone pulleys by means of which different speeds may be given to the yarn as it passes through the machine; this regulates the time that the yarn is in contact with the heated air for drying, so that there is no need of keeping it in the machine longer than necessary nor of allowing it to be reeled in a moist condition.

The dresser has tight-and-loose pulleys 10 inches in diameter, which should be driven from 120 to 140 revolutions per minute. By means of a shipping device operated by an endless rope y running entirely around the top of the machine, as shown in Fig. 1, it is possible for the operator to stop the machine from either side.

TWO-CYLINDER DRESSER

9. In the **two-cylinder dresser** shown in Fig. 3, the principal feature of difference from the machine previously described is in the method of drying the yarn, which in this machine is accomplished by means of two copper cylinders k, k_1. It is claimed as a disadvantage of this machine that the yarn is injured by contact with the heated copper cylinders without having first been partially dried by steam pipes. A dresser of the two-cylinder type is, however, very convenient to operate, because of the greater facility afforded for piecing ends that break in the machine.

Fig. 8

FOUR-CYLINDER DRESSER

10. The **four-cylinder dresser** shown in Fig. 4 is similar to the two-cylinder machine with the exception that four copper cylinders k, k_1, x, x_1 are used for drying the yarn instead of two. The object of increasing the number of drying cylinders is to increase the capacity of the machine;

Fig. 4

the greater the heating surface, the faster may the yarn be dried and the more rapidly may it be run through the machine. There is no danger of mildew if the yarn is thoroughly dried before it leaves the dresser; but, on the other hand, it is detrimental to apply too much heat to the

yarn, besides being an inconvenience to the operator. This latter point is more noticeable with cylinder dressers, which are open, than with the enclosed combination dresser.

SIZE

11. Size is not always applied to woolen yarn, and some mills rarely make use of any sizing compound whatever, claiming that it injures the brilliancy of the colors and is also disadvantageous because of the necessity of scouring it from the cloth in the finishing; the practice of sizing is becoming less common each year. On some yarn, however, there can be no doubt that the application of size is beneficial and actually necessary in order to give the yarn the strength required for weaving.

It will be understood that the constant chafing of the yarn in passing through the heddles on the harnesses tends to wear and weaken the yarn and break it; while the reed, in working forwards and backwards in beating up the filling, chafes the yarn even more than the harnesses. Very often on fibrous yarns the reed will scrape the loose fibers from each thread and collect them in *buttons* just behind the reed and in front of the harnesses. When these buttons grow large through the constant accumulation of loose fibers and the warp is drawn forwards by the take-up, the yarn will not be able to pass through the reed and so will be broken out.

It is the object of sizing to apply a mixture to the yarn that will fasten these loose fibers to the body of the yarn, thus not only increasing the power of the yarn to resist chafing but also actually increasing the strength of the yarn.

The substance generally employed as the base of sizing compounds for woolen yarn is glue. In the majority of mills pure glue and water are commonly used, the strength of the size being regulated by the character of the yarn to be treated. For instance, it would not only be unnecessary to apply a strong sizing compound to a yarn that requires but a weak size to lay down the projecting fibers, but it would be detrimental, because of the increased stiffness imparted

to the thread. On the other hand, a weak, ragged yarn requires a strong size to give it the required strength for weaving. For a very strong size the glue may be used in the proportion of 2 pounds of glue to 3 gallons of water; a weaker size may be obtained by adding more water. With a little experimenting the exact proportion of glue that will give the best results with a given yarn may easily be found.

Tallow is sometimes added to the sizing compound in order to give the yarn softness, since the tendency of the glue is to render it somewhat stiff; not more than 1 pound of tallow to 50 or 60 gallons of size is necessary. When the proportion of glue in a sizing compound is reduced, corn starch is sometimes added to make up the deficiency. The following recipe has been found to make a good size for woolen yarn: 40 gallons of water, 12 pounds of glue, 7 pounds of corn starch, 1 pound of tallow.

In sizing worsted yarn—an operation that is rarely necessary—many manufacturers do not use any glue in the sizing compound, on account of the structure of a worsted yarn being such that there are practically no projecting fibers to be glued to the body of the thread. A size for a worsted yarn should also be one that may be easily removed from the cloth, as the finishing processes of worsted goods are generally less severe than those applied to woolen goods. The following recipe has been found to produce an excellent size for worsted warps; it may be altered in strength for different yarns by the addition of more or less water, as required: 50 gallons of water, 18 pounds of corn starch, 4 pounds of dextrine, $1\frac{1}{2}$ pounds of tallow.

The amount of sizing that the yarn receives is not only regulated by the strength or viscosity of the size but also by the amount of pressure on the press, or squeeze, roll of the dresser. Referring to Figs. 2 and 3, it will be seen that if the weights f_1 are moved nearer the ends of the levers f, the pressure that the roll p exerts on the yarn will be increased and the amount of size applied decreased, since the greater the pressure the greater will be the amount of size that is squeezed from the yarn and flows back to the size pan.

DRESSING FRAME

12. When warps are made without the application of any sizing compounds, instead of using a dresser and running it without heat and without the sizing arrangement, it is much more economical and convenient to use a **dressing frame.** With the exception of those parts that are necessary for sizing and drying the yarn, the dressing frame, as shown in Fig. 5, has all the essential features of a dresser—

Fig. 5

a tying-in reed *b*, a measuring roll *d*, a lease reed *n*, and a condensing reed *o*. The yarn is taken from the spools in the creel, passed through the tying-in reed, under a leather-covered guide roll *c*, over the leather-covered measuring roll *d*, and through the lease and condensing reeds to the warp reel, upon which the sections are wound. By means of this frame the sections may be made, measured, and leased exactly as though the yarn was run through a dresser.

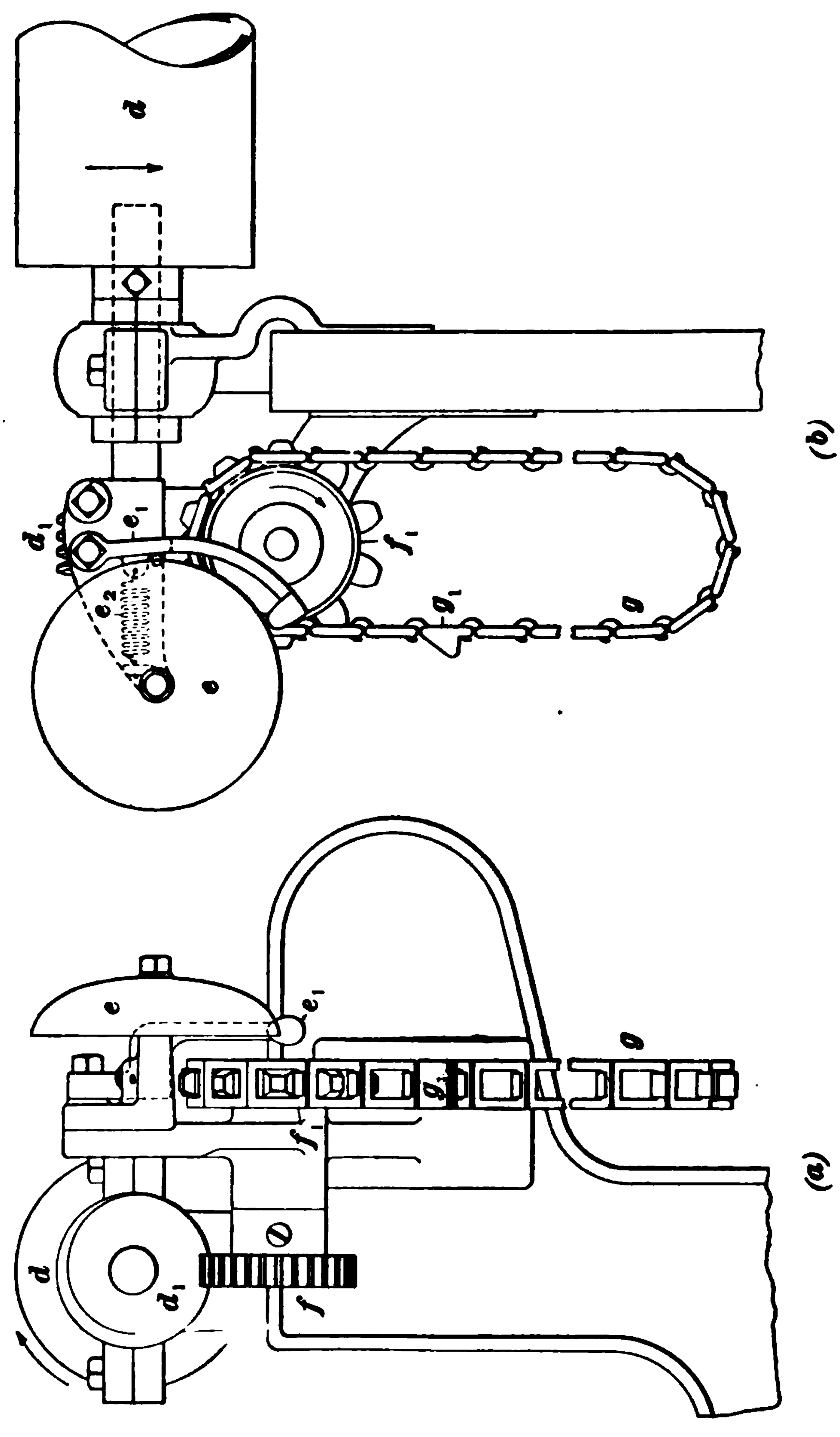


FIG. 6

At the same time, less floor space is occupied, and the machine is cheaper, simpler, and much more easily operated.

The dressing frame is provided with a **link measuring motion** for measuring the length of the sections; it is shown in Fig. 6, (*a*) being a side and (*b*) a front elevation. It is operated by the measuring roll d, which is given a rotary motion by the friction of the yarn passing over it. On the end of the measuring-roll shaft is a worm d_1 engaging with a worm-gear f fast to a short shaft, on the other end of which a sprocket gear f_1 is fastened. Running over the sprocket gear is a chain g composed of any desired number of links and containing one high link g_1, which in passing over the sprocket gear forces back and then releases a hammer e_1, which when released is drawn in contact with a bell e by means of a spring e_2. The measuring roll is 12 inches in circumference; the worm is single-threaded; the worm-gear has 30 and the sprocket 10 teeth. Therefore, three revolutions of the measuring roll will move the sprocket one tooth, or the distance of one link. Each link therefore equals 1 yard of yarn passed over the measuring roll; and the number of links in the chain, the number of yards passed through the machine.

SPOOL CREELS

COMMON CREEL

13. Fig. 3 shows a common type of *creel* for holding the spools of yarn made by the spooler. The **creel** consists of a wooden framework suitably constructed for holding the journals of the spools, so that the yarn may be readily unwound from them in being passed through the dresser. The most important point in connection with it is the method of applying friction to the spools so that they will hold the yarn at a suitable tension while it is being unwound. This is accomplished by means of a device consisting of a flat board a_1 from which a movable weight a_2 is suspended. The free end of the board rests on the top of the spool a, or rather on the

yarn wound on the spool, while the rear end is loosely supported by the creel. The position of the weight determines the amount of friction on the spool, as the nearer it is placed to the spool, the greater will be the friction. This should only be sufficient to prevent the spools from running ahead when the dresser is stopped; yet it should be enough to make a smooth, level section. Instead of having a weight hung on the friction board as shown, the weight is sometimes placed on top of the board and arranged to slide in a groove, being fastened in any desired position by means of a thumbscrew.

Although the creel shown contains twelve spools, creels may be built to contain almost any number. Generally, instead of being semicircular in form as shown, they are built only the width of one spool and are arranged for two banks of spools, one behind the other. This arrangement is to be preferred, as it is more convenient when tying in the section and also mixes the yarn better, since the yarn from each spool can be distributed over the entire width of the section without straining the reed.

IMPROVED CREEL

14. In Fig. 7, a creel, or spool rack, is shown, which, although similar in its essential features to the one described, has a few points of difference. It is constructed entirely of metal, whereas the other was made of wood; the spools are contained in bearings in a double bank, and the yarn on the back spools in passing to the tying-in reed of the dresser is carried on two light-running rolls so that it will not interfere with the spools in the front of the creel. The principal feature of this creel is the method of automatically regulating the friction on the spool. When a spool is nearly full of yarn, it is turned much more easily by the pull of the yarn in unwinding, since the pull is then exerted on a larger diameter than when the spool is nearly empty. It will therefore be seen that in order to govern the friction on the spool so that the same amount of pull will be required to

Fig. 7

turn the spool at all times, more friction should be placed on it at the start than when it is nearly empty. This is accomplished by means of a section gear *u*, Fig. 8. The friction lever, or tension paddle, *v* rests at one end on the spool *a* and at the other end on the section gear. Fig. 8 shows the position of the paddle when the spool is full and when it is empty. It will be noticed that in the former case more friction is being placed on the spool, since the tension paddle is then resting on the extreme end of the section gear. As the yarn is unwound from the spool, the fulcrum

Fig. 8

of the tension paddle is constantly shifted toward the other end of the section gear, so that the friction on the spool is constantly decreasing. This, of course, is accomplished by the heavy-weighted end of the tension paddle counter-balancing the weight of the other end. The amount of tension may be easily regulated by loosening the setscrew that fastens the section gear to the rod and moving the section gear as desired. The tension may also be adjusted by simply taking off the paddle and replacing it in a different position on the section gear.

WARP REELS

PIN REELS

15. Sectional Warp Reel.—As the yarn leaves the dresser or the dressing frame it passes through a condensing reed and is then wound upon a large reel, as shown in Fig. 2. As only one section of the warp is made at a time, it is the object of the warp reel to arrange each section in regular

FIG. 9

order side by side until the warp is formed. Fig. 9 shows a sectional warp reel suitable for use in connection with a woolen dresser or dressing frame.

This device consists principally of a large reel *w* composed of twelve bars *a*, each of which is faced with a solid

brass plate and drilled with four rows of holes, in which pins a_1 can be inserted for the purpose of separating each section and regulating the width of the section as it is wound on to the reel. The arrangement of the holes is such that an adjustment of $\frac{1}{8}$ inch may be obtained. The reel is driven by means of two belts *b* from the pulleys b_1 on the top shaft of the machine. This shaft, which is key-seated its entire length, receives its motion from a pulley on the dresser that drives the sliding pulley *s* shown in Fig. 9 (see also Fig. 2).

One of the principal features of a good warp reel is the **measuring device,** which measures the length of the sections so that the operator will be able to make each section the same. On the end of the main shaft is a single-threaded worm *c* that meshes with a worm-gear *d* so arranged as to ring a bell *e*, as in the case of similar devices used in connection with the spooler and dresser. The circumference of the reel is 4 yards and the worm is single-threaded; therefore, one tooth of the worm-gear is equal to 4 yards of the section wound on the reel.

One of the most essential features of the warp reel is the device for placing tension on the yarn when the finished warp is being beamed. Referring to Fig. 9, it will be seen that the driving belts *b* on each end of the reel pass under two tension pulleys *t*, which, with the brakes *g* that work on the heads of the reel, are controlled by means of the lever *h* upon which the weight h_1 is attached, as shown in the illustration, the lever and weight being duplicated on the other end of the machine, although not shown. While the sections of the warp are being wound on the reel, the tension pulleys are drawn together, thus tightening the belts and allowing the reel to be driven through the sliding pulley *s* from the dresser. This tightening of the belts is done by raising the weighted levers, which draw together the arms carrying the tension pulleys. When these levers are raised and fastened, the friction brakes are also raised from contact with the reel, both operations being performed by the single movement of the levers.

When, however, it is desired to unwind the yarn from the reel to the loom beam, it is necessary to place friction on the reel in order to obtain the necessary tension for winding the warp firmly. This is done by lowering the levers, which not only loosens the driving belt but also puts

Fig. 10

the friction brakes in contact with the reel. The degree of tension can be regulated with great accuracy by means of the weights on the levers, which may be moved nearer or farther from the fulcrums. On many warp reels the friction, while beaming the warp, is obtained by means of ropes passing over the heads of the reel and having weights

attached. This method, while not so convenient as the friction-brake arrangement, gives a more even tension. When beaming a warp, it is desirable to place the greatest tension on the yarn while the first part of the warp is being wound on the beam, in order that the succeeding layers of yarn may have a hard surface on which to rest.

A warp reel is always mounted on rolls or wheels that run on iron rails, so that the reel may be moved after one section of the warp is reeled, for the reception of the next section. The reel shown in Fig. 9 is built in two standard widths, viz., 92 and 111 inches, although other widths are built to order. The sliding driven pulley is $8\frac{3}{8}$ inches in diameter.

16. Patent Sectional Reel.—Fig. 10 shows a warp reel that is especially adapted for fine yarns and fancy patterns. The principal difference between this reel and the one described is in the method of adjusting the pins a_1 for the various sections. In this reel the pins are held in blocks a_1 that slide in grooves cut in the bars a of the reel. These blocks may be fastened in any position by means of thumbscrews a_2, so that the width of the section on the reel may be regulated with great exactness.

Another advantage of this device is that the pins are always in the center of the bar and not on one side; in the latter case the threads are liable to become crossed as the yarn is wound on the reel. When setting the pins on this reel it is convenient to use such a scale as is provided with the machine in obtaining the width of the sections.

PINLESS REEL

17. The **pinless reel** is designed to do away with the use of section pins, which not only require considerable time in being adjusted but also often cause the yarn at the edge of the section to be improperly wound during reeling; this results in the yarn being broken while it is being beamed. The machine shown in Fig. 11 consists of a heavy warp

reel *c* mounted on a track and, in general, very similar to the warp reels described. The reel is driven by a belt running from the dresser to a large drum *d* instead of to a flange pulley, as is usually the case. Its peculiar feature is in the method of winding the yarn, each section being wound on the reel in a cone-shaped mass that is self-sustaining without the use of pins. Each bar of the reel, as shown in Fig. 12, has mounted at one end an adjustable coning iron *b*. The first section of yarn is wound on the reel at this end and

Fig. 11

as the reel is given a positive lateral motion while the section is being wound, the yarn mounts the coning irons and is wound in the shape of a cone. The section is started on the reel between the points x and x_1, but as the reel has a lateral motion to the left, the result will be that each succeeding layer of yarn will be moved slightly to the right, mounting the coning irons until the final layer of the section is wound between the points y and y_1. The position and shape of the first section of yarn wound on the reel is shown

at *a*, while the dotted lines show the position of each succeeding section.

The lateral motion of the reel is obtained by means of a worm *e*, Fig. 11, that engages with a worm-gear f_1 fastened to a vertical shaft *f*; on the bottom end of this shaft a pinion gear f_2 engages with a rack *g* attached to the floor. As the reel rotates, this arrangement moves it on the tracks so that the yarn will mount the coning irons. The first section of yarn is built against the coning irons, as explained, but the next section wound on the reel is built against the first

Fig. 12

section, so that each succeeding layer of the second section mounts the inclined or cone-shaped edge of the first section. After the completion of each section, the reel must be disengaged from the rack and moved back to the correct position for starting the next section.

The coning irons on the end of each bar are adjustable, so that the cone may be built at any angle to suit coarse or fine yarn. The pinion on the bottom of the vertical shaft may also be changed to alter the traverse of the reel while a given length of yarn is being reeled.

In beaming, or winding the yarn from the reel to the beam, the reel is revolved in the opposite direction, and the lateral motion of the reel therefore will be reversed, causing the outside threads to remain in line with the beam heads at all times.

LEASING

18. A **lease** is an arrangement of the threads of a warp by means of which the ends are kept in their proper position and entanglements and snarls prevented. A thread lease is one in which the individual ends of the warp are alternately passed above and below two rods or cords; this serves to keep the separate ends of the warp in their proper relative position, which is essential when the warp is being drawn through the harnesses and reed.

A thread lease is obtained by means of the lease reed shown in Fig. 13. It is of peculiar construction; every alternate dent is filled with solder for a short distance at the top and also for the same distance at the bottom, thus leaving only the central part of the dent free.

Fig. 13

After the yarn has been attached to the reel, it is first depressed by means of a stick close to the lease reed, thus forming a separation of the ends, owing to every alternate dent being soldered. A string is then run through this division, after which the yarn is raised by means of the stick and another string run through. As one thread is in each dent of the lease reed, this will form a thread lease. The strings, of course, must be placed in front of the condensing reed and securely tied. A lease should be taken when starting each section of the warp on to the reel, so that it will leave the reel at the last end of the warp when the yarn is beamed.

BEAMING

BEAMER

19. After a sufficient number of sections have been placed on the reel to form the entire warp, it becomes necessary to transfer the warp from the reel to the loom beam. The reel in this case is revolved in the opposite direction, and instead of being driven by the belt from the dresser, motion is imparted to it only by the tension of the yarn in being pulled off the reel and wound on the beam. It is necessary, in order to wind the beam with sufficient firmness, to place friction on the warp reel and to disconnect the driving mechanism. The ends of the warp are taken from the reel and attached to an apron that is tacked or otherwise fastened to the loom beam, or in some cases the warp is separated in bunches and tied to ropes or cords fastened to the beam. The beam is given a rotary motion by means of a simple machine known as the **beamer,** made to unwind the warp from the reel to the beam.

Fig. 14 shows an ordinary type of beamer, known as a **double beamer,** since it is designed to beam the warps from two reels at once, if desired, as it is possible to attach a beam to each side of the beamer, so motion will be imparted to both at the same time. The machine consists of a frame carrying tight-and-loose pulleys *a* on the main shaft. On this shaft is a gear *b* engaging with a gear *c* fast to an intermediate shaft. On each end of this intermediate shaft is a gear meshing with the large gears *d*, *e*; one end of the loom beam *f* is fastened to one of these large gears by means of adjustable dogs that fit in slots in the beam head. The other end of the beam is placed in a supporting bracket *g*, which is adjustable on a plate or slide *h* fastened to the floor, so that it may be adjusted for any length of beam. The

Fig. 14

belt is guided on the tight-and-loose pulleys by means of an adjustable belt guide, so that the belt may be guided to the pulleys from any direction. This belt guide is usually arranged to be fastened in position by means of a thumb-screw. By having the large gears *d*, *e* driven as shown, greater power is obtained, since it is transmitted by two gears instead of one. Guards are placed over these gears as a protection against accidents. Fig. 15 shows another type of double beamer. The only difference is that the gears *d*, *e* are annular gears instead of ordinary spur gears; this makes a very neat and powerful beamer.

The driving pulleys of a beamer are usually about 10 inches in diameter, and the gearing is such that a speed of 150 revolutions per minute of the tight pulley will give the loom beam a speed of about 8 turns per minute, which is sufficient for beaming warps.

A **single beamer** is made similar to a double beamer, except that it has only one gear to which a beam may be attached and is designed to beam the yarn from one reel only.

COMPRESSING WARPS

20. In the ordinary method of warp preparation, the yarn is constantly subjected to tension, both in being spooled and in being beamed from the warp reel to the loom beam, with the result that its elasticity is largely destroyed and the finished goods have a *hungry* appearance. The resulting fabric is hard and boardlike, lacking the full and elastic feel that is so greatly desired in high-grade woolen and worsted fabrics. Owing to the fact that the greater the tension placed on the yarn, the greater is the amount of yarn that can be placed on spools and beams, there is a tendency to increase this tension to such a degree that the elastic limit of the yarn is very nearly reached. Goods made from yarn that has been strained to a great extent in spooling, beaming, and weaving will shrink excessively after being finished; and garments made from such

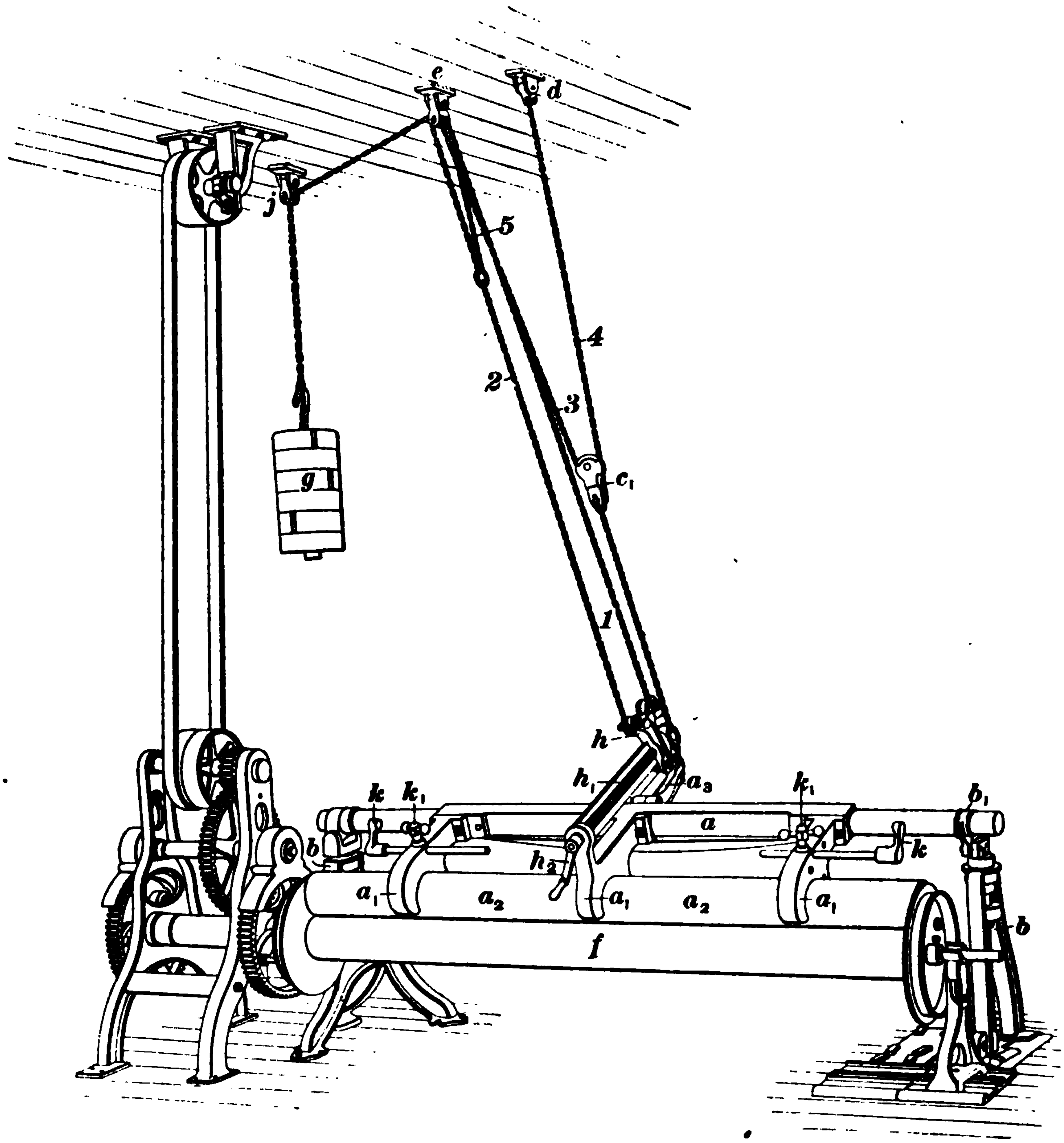


FIG. 16

(a)

Fig. 17

goods, after being worn for some time, will shrink so that they are much too small for the wearer.

It is the object of the compressing system of warp preparation to substitute compression for tension at every point in the preparation of a woolen or worsted warp where it is practicable. The system applied to warps is the same as that adopted in the compressing spooler. By this system the warp is compressed as it is beamed, which results not only in the elasticity of the yarn being retained, but also enables from 20 to 50 per cent., and in extreme cases 60 per cent., more yarn to be placed on the beam. With this system the tension on the reel is reduced as much as is practicable and the required hardness of the beam obtained by a machine known as a *warp compressor*. Compressed warps will weave better and the cloth when finished will have an elastic feeling that cannot be produced in the ordinary way.

WARP COMPRESSOR

21. Fig. 16 shows a **warp compressor** in position for compressing a warp as it is beamed, while Fig. 17 (*a*) is a section of the same machine. The machine consists primarily of a compressing roll *a*, extending the full width of the loom beam *f* and resting on top of the yarn. This compressing roll is carried in roller bearings at the end of three arms a_1 fastened to a girder shaft *a* so constructed as to withstand the great transverse strain that is necessary in order to obtain sufficient pressure to compress the warp. The compressing roll is constructed of a piece of steel tubing 64 inches in length, and by means of 10-inch, 2-inch, 1-inch, $\frac{3}{4}$-inch, and $\frac{1}{2}$-inch sections, which may be added to the end of the roll and fastened securely by means of a screw; its length may be increased so that it will fit beams from 64 up to 104 inches in width. By having the sections of the different widths above stated, $\frac{1}{4}$-inch adjustments may be obtained, so that the roll will compress the warp on any beam between the above limits. The shaft *a* is carried in bearings supported by stands *b*, and

the power for compression is obtained by means of a weight g, which is hung on a chain connected with the compressor.

The central arm, in which a bearing of the compressing roll is placed, is constructed somewhat differently from the other two arms as it extends behind the shaft a, which is the fulcrum of the compressing device. A screw h_1 mounted on this arm is turned by means of the handle h_2 and carries an adjustable block h, which contains two pulleys, around which passes a chain by means of which the compressing force is transmitted to the compressing roll. Attached to a lever a_3, loose on a stud in the arm a_1, is a chain c, to the end of which a block c_1 is attached. The weight chain is attached with one end to a casting d fastened to the ceiling and passes around the pulley in the block c_1, over a pulley in a double block e, then around both pulleys in the block h, over the other pulley in the block e, over the pulley in another block j, and has attached to its free end the weight g. While the warp is being compressed, the block h is screwed back to the position shown. Under these conditions the weight g acts through four lengths of chain *1*, *2*, *3*, *4* so that the amount of power exerted at h and transmitted to the compressing rolls is equal to four times the amount of weight g; for instance, if the suspended weight g is 80 pounds, then 320 pounds is exerted at the end of the arm a_1.

When a new beam is to be started or a full one removed, the compressor may be readily raised out of the way by simply releasing the collar b_1 on the shaft a from the stand b, whereupon the weight g will lift the compressor on the swivel bearing at the other end of the shaft a and raise it out of the way. It will be seen, however, that in order to do this, it is necessary that there should not be too great a strain on the machine; otherwise, when the collar b_1 is released, the compressor will rise with such great force that it cannot be checked. In order to relieve the strain of the weight, therefore, a short length of chain *5* is inserted between lengths *3* and *2* of the chain. When it is desired to raise the compressor, the block h is screwed forwards; this allows the lever a_3 to rise and the short length of chain *5* to be tightened.

When this is done, the weight will act through only two lengths of chain—*1* and *2*—the loop formed by the short length of chain hanging over the pulley *e* and acting exactly as though it were simply fastened to it. The pressure exerted on the compressor in this case will only be one-half as great as that exerted while the warp is being compressed, so that the machine can be more easily handled. This arrangement is shown somewhat more clearly in Fig 17 (*b*). Two pieces *k*, Fig. 16, which may be fastened in any position by means of handscrews k_1, are used to hold the compressing roll from slipping out lengthwise when the compressor is raised.

FORMATION OF WARPS

PLAIN WARPS

22. To illustrate the simplest possible operation of making a warp, suppose that a plain warp containing three cuts of 72 yards each is required. The warp is to contain 2,400 ends plus 20 ends on each side for selvage and is to be beamed 56 inches wide, this being the width of the loom beam between the heads.

23. Spooling the Yarn.—The first operation is to find out how many spools will be needed for one section of the warp. Suppose that the creel behind the dresser will hold only twelve spools and that the construction of the spooler is such that 40 ends are placed on each spool. Then it will be impossible to use more than 480 ends (12 × 40) in one section of the warp. As the warp contains 2,400 ends, five sections can be used, which will give exactly 480 ends in a section. It will be necessary, therefore, to have twelve spools made, but the length of yarn to be placed on each spool must be ascertained. The warp is to contain three cuts of 72 yards each, or 216 yards in all, and as there are five sections of the warp to be run, then each spool will have to contain five times 216 yards, or 1,080 yards.

In order to be sure of enough yarn being left in the dresser for tying the next warp, several yards more should be wound upon each spool. It is not always possible to place sufficient yarn upon a spool to run the entire warp, in which case it will be necessary to tie in extra spools during the process of making the warp.

24. Tying in.—The term **tying in** is used to designate the operation of tying the yarn on the spools to the yarn that is left in the dresser from the last warp especially for this purpose. When the spools are made for a warp, it is always planned to have enough yarn left in the dresser to which the new spools for another warp can be tied and then drawn through the dresser, for it is quite a difficult task to draw the yarn through the tying-in reed *b* and the lease reed *n*, shown in Fig. 1, as it is necessary for each end of the section to pass from the tying-in reed through the dresser to the lease reed without crossing other ends; that is, each dent of the lease reed has a corresponding dent in the tying-in reed. It is necessary for the ends to be drawn through the dresser straight; otherwise, if a fancy pattern were arranged correctly at the tying-in reed, it would not be correct at the lease reed and, consequently, in the warp.

25. In the plain warp under consideration, after having obtained the twelve spools, it is next necessary to arrange for tying them to the yarn that is left in the dresser from the previous warp and that is cut off about $\frac{1}{2}$ yard in front of the tying-in reed *b*, Fig. 1. To do this, first count out 480 ends in front of the tying-in reed, as there are to be 480 ends in a section. Then, beginning at one end of the reed with the first end of the 480, cast it up over the top of the reed; then skip 11 ends and cast up another end, and so on for the full width of the reed. When finished, 40 ends ($480 \div 12$) will be cast up over the reed. These are then knotted together and left lying over the top of the reed, being the ends to which one spool will be tied. Then proceed in like manner for the other spools as follows:

For the second spool, take one end and skip ten.
For the third spool, take one end and skip nine.
For the fourth spool, take one end and skip eight.
For the fifth spool, take one end and skip seven.
For the sixth spool, take one end and skip six.
For the seventh spool, take one end and skip five.
For the eighth spool, take one end and skip four.
For the ninth spool, take one end and skip three.
For the tenth spool, take one end and skip two.
For the eleventh spool, take one end and skip one.
For the twelfth spool, take one end and skip none.

After the eleventh spool is picked up, the remaining ends will be for the twelfth spool.

The next operation is to tie in the spools. Take the last bunch of ends that was picked in the reed and to it tie the ends of the bottom spool in the creel. Then take the next spool and tie each end to an end of the bunch that was picked from the reed next to the last. When tying in each spool, the operation should be begun at the left of the reed and each end on the spool and in the reed tied in regular order; that is, no crossed ends should be allowed. After all of the spools are tied in, the friction boards should be placed on the spools and the yarn drawn through the dresser by carefully pulling on the yarn from the front of the machine.

Sometimes when left-twist yarn is tied on to right-twist, or vice versa, great difficulty is found in pulling the yarn through the dresser, since one yarn will untwist the other. Especially is this true if one yarn contains more twist than the other. When this happens it is sometimes best not to place any friction on the spools until the new yarn is drawn through the lease reed; and also to be very careful in pulling it through.

26. Reeding the Sections.—After the section is pulled through the lease reed, it is necessary to determine the width of each section in order to determine the number of ends that must be drawn in one dent of the **condensing**, or **hack, reed** so that the sections will be wound on the warp reel the required

width. The warp is to be beamed 56 inches wide, which when divided by five sections gives 11 inches as the width of each section with 1 inch over. This 1 inch may be utilized by adding $\frac{1}{2}$ inch to the first and last sections for selvages, setting the pins so that these sections will be $11\frac{1}{2}$ inches wide on the warp reel, while the other three sections will be but 11 inches. Or, five sections 11 inches wide may be made and the selvages run outside of the pins. The width of the sections, of course, regulates both the width that the pins are set apart on the warp reel and also that of the section in the condensing reed.

Supposing that the condensing reed is a No. 15; that is, it contains 15 dents per inch. Then there will be 165 dents in 11 inches (11×15). If 480 threads, which is the number of ends in one section, are drawn 3 in a dent, they will occupy 160 dents, which is practically near enough; but by drawing only 2 threads in some dents, the sections can be made exactly 11 inches wide in the condensing reed. Each section, of course, is the same length on the reel, i. e., 216 yards, and after the reed has received the five sections it is only necessary to loosen the belts and place the friction on the reel, when the warp can be beamed. It is important to take a lease in the warp by means of the lease reed before reeling each section, as previously explained.

27. Selvages.—When winding the first section on the reel, 20 ends should be drawn through the lease and condensing reeds at one side of the section for selvage, but after the first section is wound they should be broken out and ignored until the last section of the warp is reeled, when they should be crossed over and drawn in on the other side of the section so as to form the selvage on the other side of the warp. These 20 ends for the selvage on each side may be run from bobbins that are placed on pins on the dresser.

FANCY WARPS

28. When a fancy pattern consisting of colored yarns is to be tied in, the operation of picking the ends for the spools is somewhat more difficult, since not only the spools but the pattern also must be considered. To illustrate the method of picking a fancy pattern, a pattern will be taken and the method described with reference to it. Suppose that a warp is to be made to contain 2,760 ends plus 30 ends on each side for the selvage; it is to contain five cuts, each 72 yards long, and is to be beamed 58 inches wide. The pattern of the warp is to be as follows:

WARP PATTERN

Black	20		20		20									10		10									80
Red		4				4							8		8		8		4		4				40
White				4				4				4						4		4					20
Brown							20		20		20											10		10	80
Fawn										4													6		10
Total number of ends in pattern																									230

29. Spooling the Yarn.—The first operation is to determine the number of warp patterns in one section of the warp and if (as in the previous case) the creel behind the dresser will contain only 480 ends, it is obvious that the section can contain only two patterns, or 460 ends (230×2). It is, of course, always necessary to have even patterns in each section of the warp; otherwise, there will be broken patterns in the finished warp, which will make it useless. As the warp is to contain 2,760 ends, there will be six sections in the warp ($2,760 \div 460$). It is always necessary to have the number of ends in the section divisible by the ends in a pattern and always best to have the number of ends in the warp (exclusive of selvage) divisible by the ends in a section, although it is possible when running the last section to break out some of the ends if they are not desired.

It is next necessary to find the number of spools of each color of yarn required and also the length of yarn that must be spooled. To find the number of spools of each color required in a fancy pattern:

Rule.—*Multiply the number of ends of each color in one pattern by the number of patterns in a section and divide by the number of ends on one spool (generally 40). The result in each instance will be the number of spools required of that particular color.*

Applying the above rule to the pattern under consideration,

$$\frac{80 \text{ ends} \times 2 \text{ (patterns)}}{40} = 4 \text{ spools black}$$

$$\frac{40 \text{ ends} \times 2 \text{ (patterns)}}{40} = 2 \text{ spools red}$$

$$\frac{20 \text{ ends} \times 2 \text{ (patterns)}}{40} = 1 \text{ spool white}$$

$$\frac{80 \text{ ends} \times 2 \text{ (patterns)}}{40} = 4 \text{ spools brown}$$

There are only 10 ends of fawn in one pattern or 20 ends (10×2) in one section. There are not enough for a full spool but it will be better to wind them on a spool and run them with a little less friction on that spool rather than to run them from bobbins, although this can be done. There are 12 spools ($4 + 2 + 1 + 4 + 1$), therefore, required for the section, which will just fill the creel at the back of the dresser.

30. It is next desired to find the number of yards to be spooled in order to make a warp of the required length. To find the number of yards to be spooled:

Rule.—*Multiply the number of cuts of warp by the length of a cut and by the number of sections in the warp.*

Applying the above to this particular pattern gives the following result:

$$72 \text{ yd.} \times 5 \text{ (cuts)} \times 6 \text{ (sections)} = 2{,}160 \text{ yd.}$$

From this it will be seen that there are 2,160 yards of each color required, with several yards extra to be left in the dresser for the next pattern. Unless the pattern consists of very fine yarn, this length cannot be spooled on a single spool and must therefore be wound on two or more spools, thus necessitating an extra tying in before the warp is finished. In this connection, however, it should be noticed that a single spool of fawn can be spooled containing the full number, or 40 ends, but only half the length, thus allowing 20 ends to be dressed first and afterwards the next 20 ends without removing the spool from the dresser creel.

The spools of different colors being obtained, the fawn will be placed in the bottom of the creel, then the brown, white, and red, finishing with the black in the top of the creel.

31. Picking a Fancy Pattern.—Having decided on 460 ends in the section, it is now necessary to count out 460 ends from those in the tying-in reed, after which the pattern can be picked as follows: Beginning at the left-hand end of the tying-in reed, or rather of the 460 ends counted, first pick the black, or top, row in the pattern. Pick 20 ends, then skip 4 ends for the red; then pick 20 ends and skip 4 ends for the white; pick 20 ends and skip 84 ends for the red, white, brown, and fawn, as shown by the pattern; then pick 10 ends and skip 8 for the red; then pick 10 and skip 50 ends for the other colors. As the section contains two repeats, it is necessary to repeat this operation. When this is finished, there will be 160 ends, which should be knotted together and cast over the top of the tying-in reed. These ends are the ones to which the black yarn will be tied.

It is next necessary to pick the ends for the red, which is done as follows: Beginning at the left, pick 4 ends and skip 4; pick 4 and skip 72; pick 24 ends (the black has already been thrown over the top of the reed) and skip 4; pick 4 and skip 4; pick 4 and skip 26. This operation is, of course, repeated as when picking the black.

The white is then picked as follows: Beginning at the left, pick 4 and skip 20; pick 4 and skip 44; pick 12 (the red and black are already cast over the reed) and skip 26. Repeat this operation as many times as there are repeats of the pattern in the section.

The brown is picked as follows: Beginning at the left, pick 40 and skip 4; pick 30 and skip 6; pick 10. Repeat this operation twice. The ends remaining in the reed, that is, those that are not cast over the top, will be the ends to which the fawn is to be tied.

Many dressers pick a pattern from right to left of the draft and work from right to left of the tying-in reed.

32. Tying in a Fancy Pattern.—The pattern is now picked, but as each spool is tied in separately, there is one more point that must be considered; that is, the dividing of the yarn that has been cast up for each color into sections of 40 ends each. This is done by taking each bunch of threads representing one color and picking out 40 ends as many times as possible. These 40 ends are then knotted together and thrown over the reed. It is not necessary to take these ends in any particular order, since the same color of yarn will be tied to each of them, but simply to make a selection of ends for each spool extending across the full width of the reed.

For instance, in this pattern all the ends will be thrown down and the bunch of 160 ends representing the black yarn will be picked up and 40 ends selected for each spool, each selection being made somewhat at random, but still selected so that the ends from each spool will be spread across the width of the reed. The ends for each spool can, however, be picked after the same manner as a plain warp if it is desired to have the yarn absolutely straight. The same operation is then carried out with the bunches of yarn to which the other colors are to be tied, and after completion the ends are thrown back over the reed, the ends for each spool being knotted together.

The section is now ready to be tied in, which is accomplished as follows: Take the first bunch of ends laid over

the reed, which of course will be the last color picked, or the 20 ends of fawn, and tie each end to the ends of fawn on the bottom spool in regular order. There will, of course, be only 20 ends taken from this spool. Then take the next bunch of threads and tie in the next spool, which is brown. This operation is continued until all the spools are tied in, remembering to tie each bunch of threads to its proper color; thus, in this pattern they will be tied in the following order, commencing at the bottom of the creel and working up: 20 ends of fawn on one spool, four spools of brown, one spool of white, two spools of red, and four spools of black.

33. Reeding the Sections.—After the spools are tied in with secure knots, the method of making the warp is the same as that employed in making a plain warp. As the warp is to be beamed 58 inches wide and contain six sections, four sections will be made 9½ inches wide and the two end sections, which contain selvages, will be 10 inches wide. These widths regulate the setting of the pins on the reel. Suppose that the condensing reed is a No. 12. In 9½ inches there will be 114 dents, while 460 ends, if drawn 4 in a dent, will occupy 115 dents. This is only 1 dent out of the way, which is near enough for practical purposes, although the section may be made to occupy exactly 114 dents by drawing 5 ends in 4 of the dents of the reed. The selvages, of course, will be drawn in as previously explained and the sections leased and then reeled, each section being 360 yards long (72 × 5).

SUMMARY

34. The following is a summary of the calculation of this fancy pattern and shows the data that the boss dresser will have collected for making the warp. The pattern of the warp is shown in Art. **28,** while the figuring is as follows: 230 ends × 2 (patterns) = 460 ends in section; 460 ends × 6 (sections) = 2,760 ends in warp; 30 ends on each side for selvage; [80 ends × 2 (patterns)] ÷ 40 = 4 spools of black; [40 ends × 2 (patterns)] ÷ 40 = 2 spools of red;

[20 ends × 2 (patterns)] ÷ 40 = 1 spool of white; [80 ends × 2 (patterns)] ÷ 40 = 4 spools of brown; 10 ends × 2 (patterns) = 20 ends of fawn; 72 yards × 5 (cuts) = 360 yards, length of each section; 360 yards × 6 (sections) = 2,160 yards of each color spooled; 58 inches wide on the beam; 4 sections, 9½ inches wide on the reel; 2 sections, 10 inches wide on the reel; 9½ inches in condensing reed; 4 ends per dent (5 ends in 4 of the dents).

On many fancy patterns considerable ingenuity must be exercised and often colors must be run from bobbins. Sometimes, when only a few threads of some colors are used, these colors can be wound together on one spool. However, no specific rules can be laid down for these items, since it may be said that no two fancy patterns are formed in the same manner

DRAWING IN AND REEDING

DRAWING IN

35. After a warp has been beamed it must first be drawn through the heddles of the loom harnesses, according to the drawing-in draft, and afterwards through the reed, according to the reeding particulars furnished by the designer. These operations complete the preparation of the warp and it is then ready to be placed in the loom and woven.

The **harness**, Fig. 18 (*a*), is a wooden frame attached to the shedding mechanism of the loom by means of which it may be raised and lowered to form an opening, or shed, in the warp through which the shuttle carrying the filling yarn can be thrown. At the top and bottom of the harness frame two steel heddle bars a_1, a_1 are placed; these bars are usually fastened at one end by means of threaded stretcher hooks and nuts, while at the other end they pass through a slot in the harness frame and are secured by hooks that engage with holes in the heddle bars. Heddles, Fig. 18 (*b*), twisted from wire are threaded on the heddle bars, and in addition to the eyes required at each end for this purpose

are made with an eye at the center through which an end of the warp may be drawn. Any reasonable number of heddles may be placed on the harness frame, the number required depending on the number of ends in the warp and the number of harnesses to be used. The drawing-in draft also may require more heddles on some harnesses than others, but extremes should be avoided, since if the heddles are too crowded the warp will run poorly in the loom. When the harnesses are very wide, hooks a_2, Fig. 18 (*a*), are inserted in the frame to support and stiffen the heddle bars.

36. Drawing-In Frame.—In order that the warp may be drawn through the harnesses in the most convenient

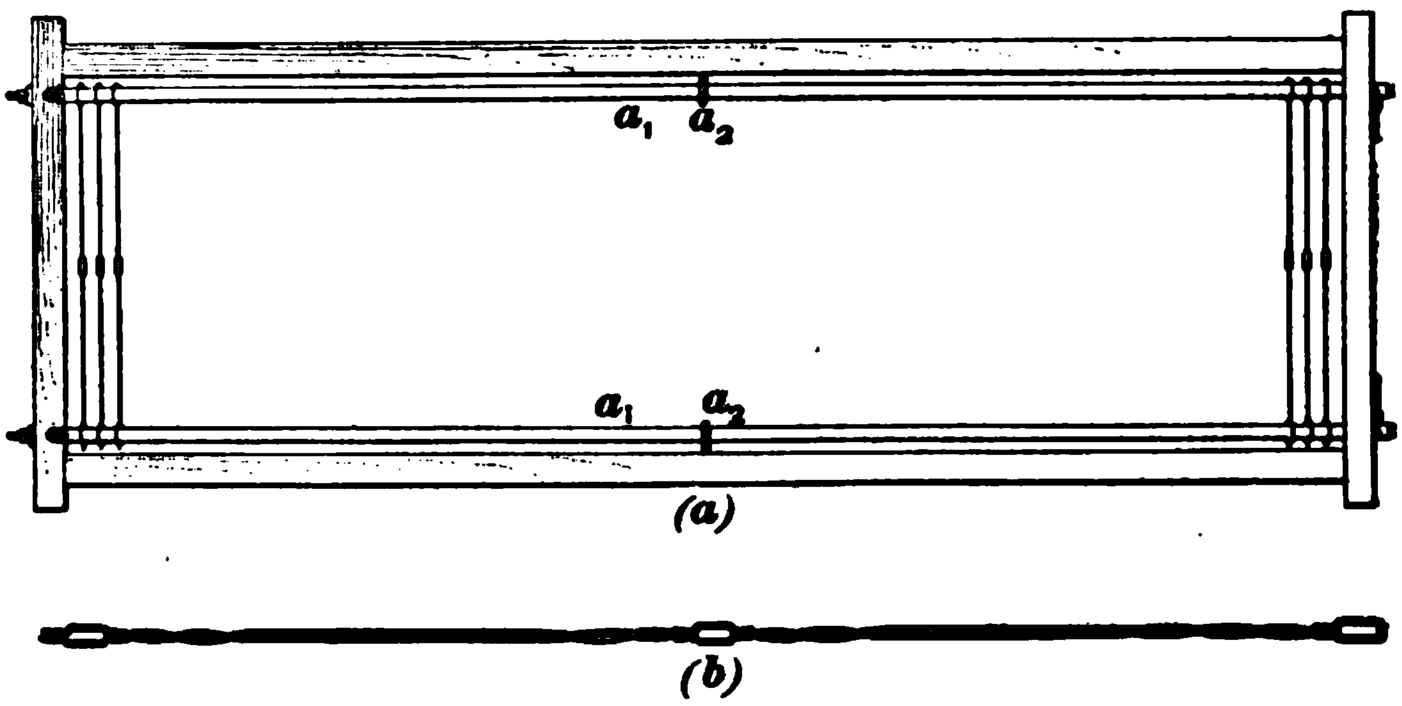


FIG. 18

manner, a drawing-in frame similar in principle to that shown in Fig. 19 is necessary. An iron drawing-in frame may be purchased, but it is usual for the mill to construct its own drawing-in frames, since a very simple arrangement is all that is necessary. As shown in Fig. 19, the essential features are two stands *a* for supporting the beam and a framework *b* over which the warp may he drawn. The two arms b_1 bolted to this frame support the harnesses, while the lease of the warp hangs from the supporting beam b_2 directly behind the heddle eyes of the harness. The strings that have retained the lease in the warp are replaced by two lease rods *c* that are placed through the lease and tied together at each end after which the lease strings may be withdrawn.

FIG. 19

37. Method of Drawing in a Warp.—The operation of drawing in a warp is as follows: The order in which the ends are to be drawn through the harnesses is usually indicated by a draft similar to that shown in Fig. 20, furnished by the designer. In this draft the horizontal rows of squares represent the harnesses as indicated, the draft being made in this case for a warp that is to be drawn in on eight harnesses. The vertical rows of squares indicate the warp ends, and the figures on these vertical rows of squares indicate through which harness each end is to be drawn. When drawing in, the operator commences at the right of the warp and of the harness frames and draws in the first end of the warp on the harness indicated on the first vertical row of squares at the right of the drawing-in draft. This operation is then repeated

											8				8	8th Harness
										7				7		7th "
									6				6			6th "
								5				5				5th "
			4				4									4th "
		3				3										3rd "
	2				2											2nd "
1				1												1st "

FIG. 20

with the next end, and so on, the warp being drawn from right to left. For instance, according to the draft in Fig. 20, the first end of the warp on the right will be drawn through the eighth, or back, harness, the second end through the seventh harness, the third end through the sixth harness, the fourth end through the fifth harness, the fifth end through the eighth, and so on throughout the draft. When the last end of the draft is drawn in, the whole operation is repeated, commencing again at the right of the draft. When the ends are drawn through the harnesses in regular order from back to front or front to back, the draft is said to be a *straight draw*, but when the ends are drawn in any other order, the draft is is said to be a *cross-draw*. The operation of drawing in is generally performed by a girl, called a *drawer-in*, and in cases where a large number of harnesses are used or where the

drawing-in draft is quite complicated, another girl, called a *hander-in*, assists. The drawer-in grasps the required heddles in her left hand and inserts a hook, called a *reed*, or *drawing-in, hook*, Fig. 21, in the eye of the heddle, while the hander-in hooks the required thread, as indicated by the lease, in the eye of the hook; the drawer-in then draws the thread through the heddle eye and inserts the hook in the next heddle, and so on. The drawer-in sits in front of the harness frame, Fig. 19, while the hander-in sits in the rear,

FIG. 21

underneath the yarn; this is the reason for building the drawing-in frame with two bars b_2, b_3 over which the warp is passed. In cases where no hander-in is required, the drawing-in frame may be constructed with only one bar b_2. As fast as a number of ends are drawn through the heddles, the drawer-in makes two bunches of the yarn and ties a half knot in front of the heddles so as to prevent the ends from being accidentally pulled out.

REEDING

38. After the ends of the warp have been drawn through the harnesses they must be drawn through the **reed,** which is a gratelike device placed in the lay of the loom for the purpose of beating up each pick of filling as it is inserted in the cloth; it also separates and distributes the warp ends across the width of the cloth. A reed is constructed of thin, flat strips of steel set edgewise in two pieces of wood called **ribs,** as shown in Fig. 22. Each rib is made in two parts that are wound with waxed cord in order to space the strips and make the whole reed firm. The space between two adjoining strips of steel in the reed is called a **split,** or **dent,** the latter being the term generally employed. The number of dents in a given space is largely determined by

the size of the waxed cord with which the ribs are wound, since the thicker the cord, the greater will be the space between the strips. The number of dents in a given space determines the number of the reed. The general custom is to use for this given space 1 inch; thus, a 10s reed contains 10 dents per inch. In the English woolen trade $\frac{1}{4}$ yard, or 9 inches, is sometimes used; thus a 90s reed of this system is the same as a 10s reed of the American system. Sometimes, especially in the cotton trade, the number of dents in a given number of inches is used to designate the number of the reed; thus, a 1,200 – 30 reed, which indicates that there are 1,200 dents in 30 inches, is equal to a 40s reed. The height of the reed, or the length of the steel strips measured between the ribs, is governed by the class of fabric to be woven and the kind of loom for which it is designed. For instance, for cotton a $3\frac{1}{2}$-inch reed is high enough, while woolen and worsted require from a $4\frac{1}{2}$- to a 6-inch reed. Carpets and other heavy fabrics often require as high as from 8 to 9 inches. The coarser the reed, the less friction to a certain extent will there be on the warp; on the other hand, the finer the reed, the smoother will be the fabric. Reeds that have become bent or otherwise damaged by careless handling produce stripes in the cloth, known as **reed marks**, owing to the imperfect spacing of the warp. Sometimes if too many of the warp ends are drawn in one dent of the reed they will roll or ride each other. This may be remedied by using a finer reed and drawing less ends in one dent.

Reeding is usually accomplished by means of a hook somewhat different from the one employed in drawing a warp through the harnesses, as shown in Fig. 23. The hook is passed through a dent of the reed and a number of ends,

depending on the number to be drawn through this particular dent, are engaged and drawn through the reed as the hook is withdrawn. The hook is then inserted in the next dent and the ends drawn through in a similar manner. The number of ends drawn through a dent of the reed may vary in different cases, and sometimes with the same warp the reeding particulars may call for a different number of ends in some of

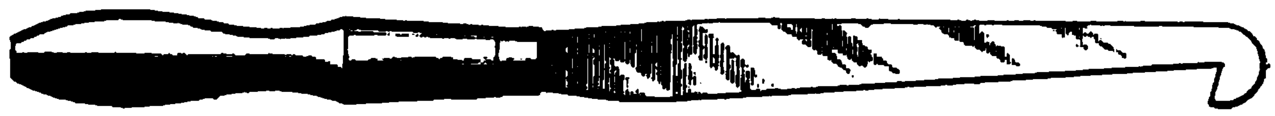


FIG. 23

the dents; but in any case the ends must be reeded in the same order as they are drawn through the harnesses. When reeding, the operator works from right to left in the same manner as when drawing in the warp, and ties the warp in half knots in front of the reed so that there will be no danger of the ends being pulled out of the reed.

TWISTING IN

39. After a warp has been nearly woven out in the loom, if the new warp that is to replace it has the same number of ends and is to be woven with the same drawing-in draft, considerable time and labor may be saved by twisting it in. When this can be conveniently performed in the loom, a lease is made in the old warp by raising every alternate harness and inserting one lease rod, and then depressing these harnesses, raising the others, and placing another rod in the shed. This forms the lease, which facilitates the twisting in of the ends in their proper order. The new warp is then placed in the loom and the ends twisted to those of the old warp. This is done by taking the threads of the two warps in the proper order with the right hand, and taking out the twist with the left hand, and then laying back the two ends and rolling them firmly together. Each end of the new warp is twisted to the corresponding end of the old warp in this manner, and the new warp is then carefully drawn through the harnesses and reed. While the twist is

not sufficiently strong for weaving, it is strong enough to enable the new warp to be drawn through the harness and reed without difficulty if care is taken. When twisting in, the operative generally dips his fingers in whiting and oil, which allows the threads to be more firmly secured.

40. Twisting-In Frame.—When it is not convenient to twist in the new warp in the loom, a frame, made especially for the process of **twisting in,** must be provided. This frame, Fig. 24, consists of stands *a* for supporting the warp beam *c*, and a stand *b* for carrying the harnesses *d* and the reed *e*, which is usually tied to the harnesses in order that it may be held securely in place. The old warp is cut out of the

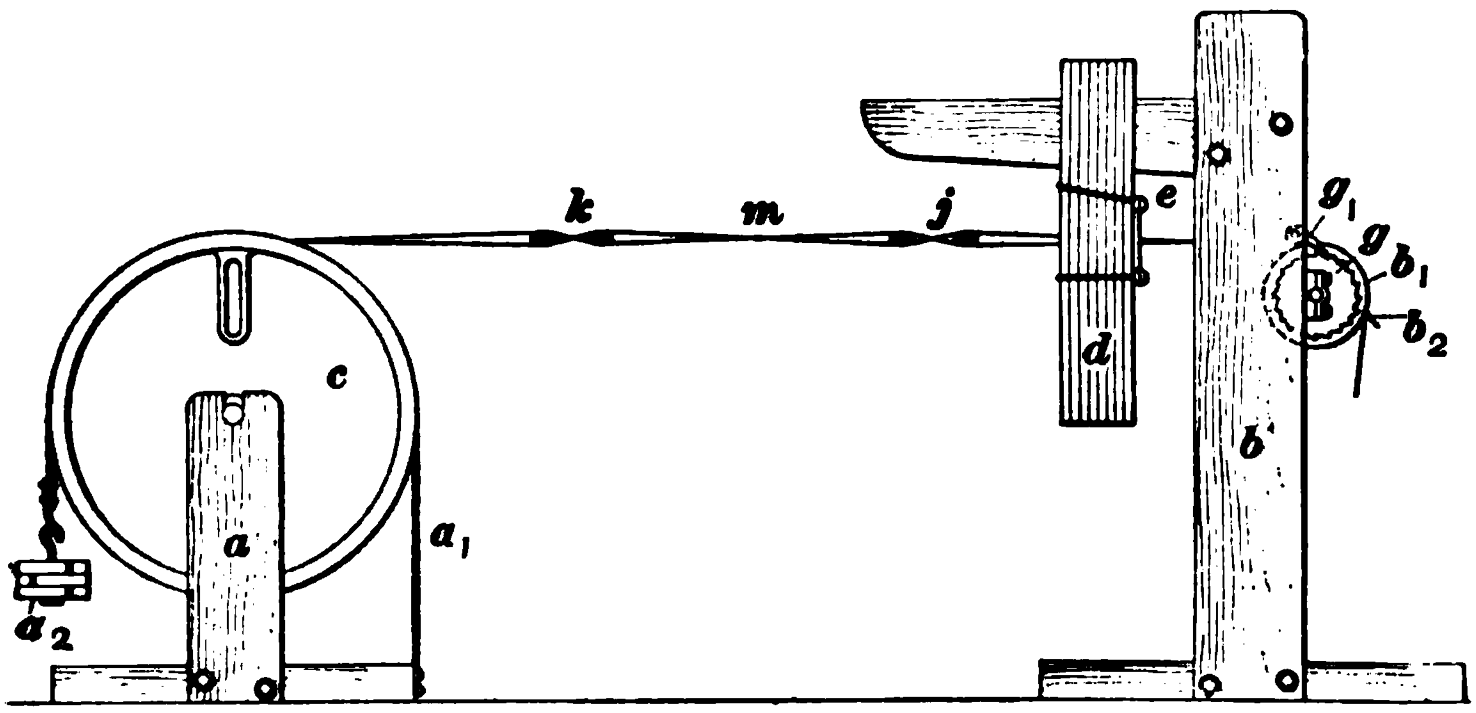


FIG. 24

loom, after a lease *j* has been taken, with a small piece of the woven cloth attached. This cloth is secured to a drum b_1 by means of pins b_2. A ratchet *g* and pawl g_1 prevent this drum from turning and slackening the warp while it is being twisted in. The new warp having a lease at *k* is placed in its stands and each end twisted to an end of the old warp at *m*. A strap a_1 and weight a_2 prevent the beam from turning. After the warp is all twisted, the friction is taken off the beam and the drum b_1 rotated until the new warp is drawn through the harnesses and reed, after which the old warp is broken. The ends of the new warp may now be knotted loosely in front of the reed and the warp placed in the loom.

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NOTE.—All items in this index refer first to the section and then to the page of the section. Thus, "Alpaca 27 30" means that alpaca will be found on page 30 of section 27.